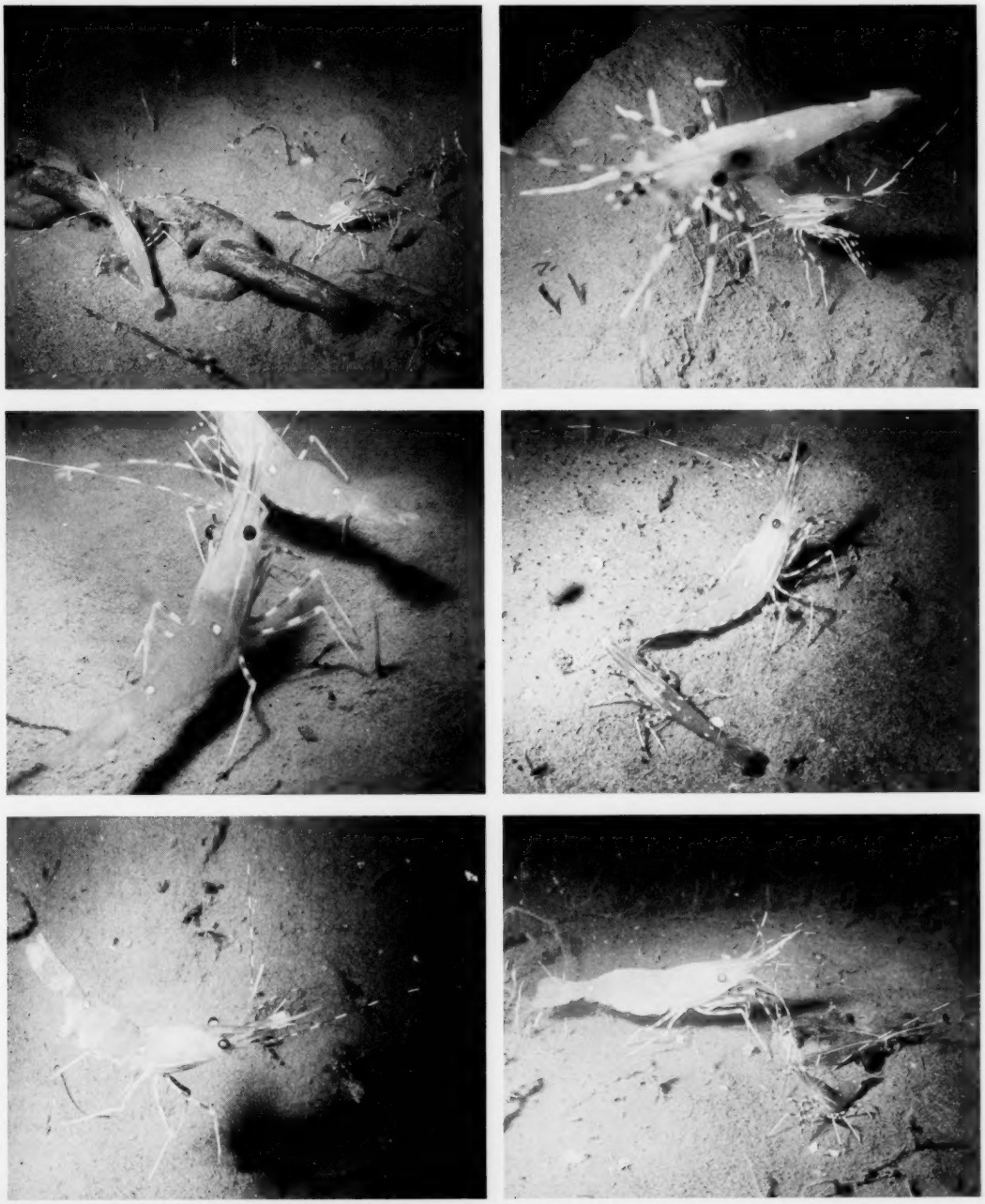
Volume 40 • Number 9 • September 1978

Marine Fisheries REVIEW

National Oceanic and Atmospheric Administration • National Marine Fisheries Service



Marine Fisheries Review

Vol. 40, No. 9
September 1978

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Cover: Shrimp photographs by William L. High, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. East, Seattle, WA 98105.

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National Marine Fisheries Service

Marine Fisheries Review is published monthly by NMFS Scientific Publications Staff, Room 450, 1107 N.E. 45th St., Seattle, WA 98105.

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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through May 31, 1980.

Managing Editor: W. Hobart

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Price $1.10 (single copy). Subscription price: $12.75 a year, $15.95 a year for foreign mailing. Controlled circulation postage paid at Tacoma, Wash.

MFR PAPER 1324

Composition of the Edible Portion of Raw (Fresh or Frozen) Crustaceans, Finfish, and Mollusks. III. Microelements

VIRGINIA D. SIDWELL, AUDREY L. LOOMIS, KAREN J. LOOMIS, PAULINE R. FONCANNON, and DAVID H. BUZZELL

ABSTRACT—This report summarizes data from 224 publications referring to the microelements found in the flesh of commonly eaten seafoods. These microelements are: Copper, iron, zinc, iodine, manganese, mercury, organic mercury, lead, arsenic, fluorine, silver, cadmium, cobalt, selenium, chromium, vanadium, tin, aluminum, nickel, barium, and molybdenum.

INTRODUCTION

In Part I of this series, Sidwell et al. (1974) described the data bank being established at the Southeast Fisheries Center of the National Marine Fisheries Service, NOAA, and outlined the system that would be employed for management and retrieval of the data.

The objectives of the data bank are: 1) To develop a comprehensive, systematic data retrieval system containing information on the chemical and nutritional composition of seafoods; 2) to publish information on the nutrients in fishery products (by surveying the literature); and 3) to point out aspects of the chemical composition of fish needing further investigation. Part I also summarized the data on the content of protein, fat, moisture, ash, carbohydrates, energy (calories), and cholesterol in commonly eaten seafoods.

In Part II, Sidwell et al. (1977) reviewed the data on the concentrations of sodium, potassium, calcium, phosphorus, chlorine, and magnesium found in edible portions of seafoods.

Part III summarizes the available data on the concentrations of various microelements (trace elements) in seafood. There is a need for such information in the medical community, e.g., in the evaluation of nutritional aspects and in the calculation of special diets. There is also a need for such data in the fishing industry, because high contents of certain microelements in fishery products may cause public health concern or invoke legal restraint of the products' sale. The nutrition-conscious consumer also wants to be aware of the positive nutritional aspects of the fish he or she buys, as well as the possible contamination.

The authors are with the College Park Laboratory, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, College Park, MD 20740. (New address: Charleston Laboratory, P.O. Box 12607, Charleston, SC 29412.) *This is Contribution No. CP463 from the Southeast Fisheries Center, College Park Laboratory.*

RESULTS AND DISCUSSION

In this report, Part III, we assembled data from 224 references on microelements found in 167 different species of the most commonly eaten fish and shellfish. These microelements are: Copper, iron, zinc, iodine, manganese, mercury, organic mercury, lead, arsenic, fluorine, silver, cadmium, cobalt, selenium, chromium, vanadium, tin, aluminum, nickel, barium, and molybdenum.

The averages and ranges for each microelement were calculated from the data reported by various investigators. These data may have been in the form of an average based on multiple determinations, or they may have been reported as individual values for which an average could be calculated. Regardless, only the averages were used to calculate the overall averages in Tables 1, 2, and 3. With the overall average and range is the number of averages used in the calculation of the two statistics.

Sometimes the average appears as 0.0 ppm (Tables 1, 2, and 3). This means the investigator either reported no detectable amount or the amount was less than 0.05 ppm; therefore, to fulfill the criteria set up for the format of the tables the figure was rounded off to 0.0.

Only a limited number of analyses are available for many species of fish and shellfish listed in Tables 1, 2, and 3. Also, a number of species of commonly caught fish have not been analyzed for microelement content. Whenever the information for a specific fish or element is limited, the listed value should be regarded only as an estimate of what can be expected. More data are necessary to obtain a value which possesses a notable degree of reliability.

Excellent and reliable data on the microelement content in the flesh of commercially important species harvested from the coastal waters of the United States, Hawaii, and Alaska, can

be noted in Hall et al[1]. The data reported were generated over a period of 5 years at the Southeast Fisheries Center's College Park Laboratory of the National Marine Fisheries Service. None of those data are included in this report. However, the publication by Hall et al. does not fully fill the gaps that are evident in this summary.

The literature we researched contains minimal information on: 1) The physiological need for microelements in fish muscle; 2) the physiological interrelationships between the elements; and 3) how much of an element can be expected to be naturally present in the fish muscle.

In Tables 1, 2, and 3 the range of values for each element in the flesh of the same species of animal is sometimes quite large. A portion of this variation is undoubtedly associated with seasonal and biological differences, i.e., the animal's size, age, sex, degree of sexual maturity, and elements present in its diet. Some of the variation may be related to the technique used in preparing the sample before it is analyzed or the method of analysis used by the investigator. High figures in some cases may reflect environmental contamination.

In Table 1, mercury and organic mercury are the only elements that are of public health concern. The Food and Drug Administration (FDA) has set a guideline for maximum acceptable mercury content of foods at 0.5 ppm. With the exceptions of burbot, cuttlefish, goby, perch, shark, stargazer, swordfish, and weever, the mercury contents reported here fall within the limits of the guideline.

The other elements listed in Table 1—copper, iron, zinc, iodine, and manganese—are of known nutritional importance. A 100-g portion (approximately 3½ ounces) of raw flesh will often make a significant contribution to the daily requirement for the elements.

In Table 2 the following elements may be of public health concern: Lead, arsenic, fluorine, cadmium, and selenium. Historically, they are known to be toxic to humans and terrestrial animals if the dietary intake is excessive. Yet, small amounts of fluorine and selenium are nutritionally important. Fluorine plays an important role in preventing dental caries in children and in maintaining the rigidity of the bones of the elderly. Selenium is the metallic component of an enzyme, xanthine oxidase, which plays a role in protein metabolism. No such nutritional need has been observed for lead, arsenic, or cadmium. Certain mollusks—mactra clams, oysters, and whelks—contain more lead than other species of sea animals. Arsenic is also present in varying amounts in the flesh of many finfish and shellfish. The elemental state of arsenic is known to be more toxic to humans than the organic forms. The possible function of arsenic in marine life is not known. Cobalt, also listed in Table 2, is important as an integral part of the vitamin B_{12} molecule. Since vitamin B_{12} is not concentrated in animal flesh, a low content of cobalt is expected.

The data for the metals listed in Table 3 are based on too few species for any conclusions to be drawn. Nutritionally, there are indications that chromium, vanadium, and tin are important food constituents for the maintenance of good health. More extensive research needs to be conducted in reference to these metals and their requirement by humans. Aluminum is found universally in all plants and animals.

The data for each species of finfish, crustaceans, and mollusks were obtained from the bibliography listed in Table 4.

The literature review summarized in this report will provide the medical community with an estimate of the content of various microelements found in seafood for the calculation of special diets involving minerals needed or to be avoided by the patients. It will help make the fisherman and processor aware of possible contamination in certain species of fish, which may present marketing difficulties. The information reported on the nutritional value of many of the elements seen to be present in seafood will be useful to those concerned with consumer education.

[1]Hall, R.A., E.G. Zook, and G.M. Meaburn. 1978. National Marine Fisheries Service survey of trace elements in the fishery resource. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-721, 313 p.

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(Literature citations continue on page 17.)

Table 1.—Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks. III Microelements: Copper, iron, zinc, iodine, manganese, mercury, and organic mercury.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Abalones Haliotidae	24.1	23.5 7.9-30.0 5	9.7 0.8-21.10 3	1.1	0.5		
Anchovies Engraulidae	2.9 0.8-5.0 2	19.8 8.1-49.0 9	15.0		0.4 0.0-0.7 2	0.1 0.0-0.3 6	0.1
Argentines Argentinidae							0.0
Barracudas Sphyraenidae		6.8 1.1-12.7 6	2.1	0.3			
Basses, sea Serranidae	1.2 0.0-4.0 8	12.3 1.9-41.0 18	18.0 1.4-50.0 3	0.2 0.1-0.4 4	0.4 0.0-1.1 4		
Basses, temperate Percichthyidae		13.1 4.2-22.0 2	2.7	0.4 0.4-0.5 2	0.3	0.3 0.1-1.0 7	0.9
Batfishes Ogeocephalidae		11.0					
Beardfishes Polymixiidae	2.5						
Billfishes Istiophoridae		4.7 1.4-8.0 2	0.8		2.4 0.1-4.8 5		0.9
Bluefishes Pomatomidae	0.2 0.2-0.3 2	22.7 6.0-52.0 3		0.3 0.3-0.4 3	0.0 0.0-0.0 2		
Bombay ducks *Harpodon nehereus*		43.3 12.0-105.0 3					
Bowfins Amiidae				0.0		0.4	
Burbots Lota				0.8		5.1 0.1-21.9 7	
Butterfishes Stromateidae		67.4 9.0-122.3 6		0.1			
Butterflyfishes Chaetodontidae		8.8 4.6-11.0 3	7.8		0.0		
Caesios Caesionidae		6.0 5.1-6.9 3					
Catfishes, airbreathing Clariidae	1.5	10.0 4.8-19.0 4			0.0		
Catfishes, airbreathing Heteropneustidae	4.8 1.5-8.0 3	26.0 22.6-31.0 2					
Catfishes, freshwater Ictaluridae	1.1 0.6-1.7 4	14.7 3.6-26.9 10	0.0 11	1.0	0.6	0.2 0.0-0.5 11	0.4 0.2-0.5 3
Catfishes, sea Ariidae	0.6	33.3 4.8-63.7 10	0.1 0.1-0.2 2	0.1 0.0-0.2 2	0.0		
Cavefishes Amblyopsidae		5.2					
Characins Characidae		14.7					
Chubs, sea Kyphosidae	0.0	10.0			0.0		

Table 1.—continued.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Cichlids Cichlidae		18.0 4.0-32.0 2					
Clams, arkshell Arcidae		57.1					
Clams, donax Donacidae	0.7						
Clams, freshwater Mixed species			30.0		10.0		
Clams, mactra Mactridae	0.9 0.7-1.1 2				0.2	0.1 0.0-0.2 3	
Clams, razor Solenidae		42.2 5.0-110.0 8	77.0	1.4		0.1	
Clams, softshell Myacidae	2.5			45.5 1.1-90.0 2			
Clams, tellin Tellinidae		86.0					
Clams, Venus Veneridae	4.3 0.0-19.2 10	59.6 16.0-130.0 12	27.5 5.1-77.0 11	0.8 0.2-1.4 5		0.1 0.0-0.3 18	
Cockles Cardiidae		43.3 28.0-78.0 4			1.8 1.6-2.0 2	0.0 0.0-0.1 2	
Cods, Atlantic *Gadus morhua*	0.3				0.1 0.0-0.2 7		0.0 0.0-0.0 3
Cods *Gadus* sp.	3.3 0.2-5.5 7	8.9 3.4-42.9 9	31.3 9.0-52.5 3	1.0 0.2-5.0 10	0.2 0.0-0.5 7	0.2 0.0-0.8 9	1.0
Codfishes Gadidae	2.6 1.1-19.4 24	8.1 3.4-42.9 31	17.0 2.8-52.5 12	1.5 0.1-6.0 26	0.2 0.0-0.6 16	0.2 0.0-0.8 49	0.0 0.0-0.0 10
Crabs Mixed species	9.2 0.1-50.7 28	21.9 2.5-61.0 22	41.3 14.0-93.6 18	1.2 0.1-4.6 11		0.2 0.1-0.5 6	0.1 0.0-0.1 2
Crayfishes Mixed species	20.4 0.1-167.0 18	47.3 4.4-373.0 11	27.0 1.5-66.0 13	1.0 0.3-1.4 4	1.5 0.1-4.2 7	0.2 0.0-0.5 11	0.1
Cusk eels and brotulas Ophidiidae	1.2 1.0-1.4 2	7.2 5.0-9.4 2	6.0				
Cutlassfishes and hairtails Trichiuridae	1.7 1.0-2.3 2	35.0 6.0-138.7 5	5.0	0.1			
Cuttlefishes Mixed species	4.2	30.0 11.0-49.0 2			1.1	2.7 0.9-5.1 3	
Dolphins Coryphaenidae		17.0		0.2		0.2 0.1-0.3 2	0.3
Dories Zeidae	0.0	10.0			0.0	0.2 0.1-0.3 2	
Drepanes Drepanidae		5.0 4.0-7.0 3					
Drums Sciaenidae	0.9 0.1-2.1 7	17.4 0.8-79.2 27	3.6 0.7-7.6 6	0.2 0.0-0.6 9		0.2 0.1-0.4 7	

Table 1.—continued.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Eels, conger Congridae	2.0 0.0-6.0 5	12.8 5.0-40.0 7	8.8 8.7-9.0 2		0.1 0.0-0.3 2	0.4 0.1-0.7 5	
Eels, freshwater Anguillidae	0.9 0.2-1.7 3	18.6 5.0-54.4 6	18.1 6.2-30.0 2	0.8	0.3 0.3-0.3 2	0.7 0.1-3.1 13	0.4 0.2-0.6 5
Eels, moray Muraenidae		4.8					
Eels, pike conger Muraenesocidae	0.3	13.6 0.8-42.4 5	0.6				
Eels, snake Ophichthidae	1.5 0.4-3.8 4	96.6 2.9-350.0 11	5.5 5.4-5.7 2		0.0	0.2 0.2-0.3 2	
Eels, snipe Nemichthyidae						0.0	
Eels, spiny Notacanthidae	0.0	258.4 4.3-512.5 2					
Eels, swamp Flutidae		22.0					
Eelpouts Zoarcidae	2.4	9.4				0.0 0.0-0.0 2	
Featherbacks Notopteridae		83.8 4.2-225.0 6				1.7	
Flatheads Percophididae		7.5 1.2-13.0 4	1.3	0.2	0.2 0.0-0.4 2		
Flounders Bothidae	0.6 0.1-1.2 2	5.1 3.3-6.9 4	3.1	0.2	0.2 0.2-0.3 2	1.8	
Flounders Pleuronectidae	1.7 0.1-7.0 16	7.9 0.4-22.0 26	4.6 0.8-14.2 9	0.4 0.1-1.0 19	0.4 0.0-1.8 9	0.2 0.0-0.8 27	0.0 0.0-0.1 5
Flyingfishes and halfbeaks Exocoetidae	0.0	10.3 5.1-14.5 5			0.1 0.0-0.1 3	0.3	
Gars Lepisoteidae	1.0	7.0	5.0	0.0		0.2 0.2-0.3 4	
Gillrakers Chirocentridae		34.0					
Goatfishes Mullidae		8.8 5.1-11.0 4			0.0	0.1 0.1-0.1 3	0.1
Gobies Gobiidae	2.2 0.3-4.0 2	19.4 1.0-82.4 11	6.0	0.1	0.0	1.5 0.2-2.8 2	
Goosefishes Lophiidae		12.5 10.0-15.0 2				0.7 0.2-1.3 2	0.1
Greenlings Hexagrammidae	4.1	4.9 0.2-9.6 2	0.3	0.2 0.1-0.2 2	0.3	0.3 0.1-0.4 4	
Grenadiers Macrouridae	4.0	9.0	6.0				
Grunts Pomadasyidae	0.8 0.0-1.6	11.7 1.0-22.5 8	29.7 8.4-51.0 2				

Table 1.—continued.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Guitarfishes Rhinobatidae	0.6	2.6	2.0 1.0-3.0 2		0.3		
Gurnards, flying Dactylopteridae	0.1	14.2 10.0-18.0 4	0.9		0.0	0.5	
Haddocks *Melanogrammus aeglefinnus*	1.5 0.1-2.4 10	8.5 3.5-14.0 12	7.8 2.7-17.4 3	3.1 0.3-6.0 8	0.2 0.2-0.2 2	0.1 0.0-0.2 9	0.0 0.0-0.0 2
Hakes *Merluccius* sp.	0.1 0.1-0.1 2	7.9 5.0-11.6 3	19.0 8.0-30.0 2		0.2 0.1-0.3 2	0.3 0.1-0.5 10	0.0
Herrings Clupeidae	1.7 0.1-2.3 4	10.9 0.0-31.2 13	1.7	0.2 0.0-0.5 5	0.1 0.0-0.2 3	0.2 0.1-0.3 4	0.1
Jacks and pompanos Carangidae	0.4 0.0-1.1 6	17.3 0.1-82.1 37	3.7 0.0-9.0 7	0.3 0.1-0.6 6	0.3 0.0-0.5 6	0.2 0.1-0.8 5	0.1
Lampreys Petromyzontidae		9.0				0.4 0.1-1.1 3	
Lanternfishes Myctophidae						0.0 0.0-0.1 2	
Lings Molva		6.7 5.0-8.0 3		2.1 1.2-3.0 3		0.1	
Lizardfishes Synodontidae		3.5 0.2-6.0 3	0.4				
Longarays Ambassidae		5.4					
Lumpfishes and snailfishes Cyclopteridae		14.0				0.0	
Mackerels *Scomber* sp.	0.9 0.3-2.0 4	29.3 0.7-84.9 7	1.0	0.4 0.1-1.0 8	0.0	0.1 0.0-0.3 5	
Mackerels *Scomberomorus* sp.	0.5	16.1 0.6-40.2 8	1.9 0.6-3.2 2	0.2 0.1-0.4 3	0.0	0.6 0.1-1.1 2	
Mackerels and Tunas Scombridae	1.4 0.0-3.4 14	23.5 0.7-84.9 55	1.2 0.2-3.2 5	0.4 0.1-1.0 21	0.2 0.0-0.5 8	0.4 0.0-1.4 64	0.5 0.4-0.5 3
Milkfishes Chanidae		7.1 3.2-11.0 2				0.0	
Minnows and carps Cyprinidae	2.2 0.5-6.1 13	16.0 5.0-56.0 17	35.0 10.0-60.0 2	0.9 0.0-3.1 10	0.6 0.0-2.3 7	0.3 0.1-0.9 13	0.5 0.1-1.1 6
Mojarras Gerreidae		4.2 4.0-4.4 2					
Mooneyes Hiodontidae						0.2 0.1-0.3 4	
Mullets Mugilidae	1.0 0.0-2.1 9	27.1 1.0-250.0 25	3.3 0.8-5.3 4	1.9 0.1-4.9 6	0.0 0.0-0.0 2	0.1 0.0-0.2 6	0.1
Mussels Mytilidae	2.2 0.2-3.6 6	76.7 10.0-127.0 5	33.7 20.0-44.8 4	1.4 0.8-1.9 2	2.3 0.0-4.6 4	1.5	

Table 1.—continued.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Needlefishes Belonidae	4.2	11.3 9.8-14.0 3		1.9			
Nemipterids Nemipteridae		3.3 1.4-5.5 3	1.0				
Octopuses Mixed species		14.7 0.9-2.5 3	16.2	0.2	0.1	0.3 0.3-0.4 2	
Oysters Ostreidae	79.3 0.3-606.0 52	54.8 8.9-101.6 27	844.0 71.0-2000.0 31	0.6 0.1-1.3 19	3.3 0.1-6.5 14	0.1 0.0-0.2 9	
Parrotfishes Scaridae						0.1	0.1
Perches Percidae	1.7 0.0-3.7 6	7.6 4.8-10.0 4	12.0	0.0 0.0-0.0 3	0.2 0.0-0.4 5	1.2 0.1-15.7 56	0.6
Perches, climbing Anabantidae	1.3 1.0-1.6 2	18.6 3.4-76.0 7					
Periwinkles Littorinidae				0.8	28.4		
Picarels Centracanthidae						0.3	
Pikes Esocidae	2.0 0.7-3.4 9	7.5 0.4-43.1 10	13.2 4.0-19.0 4	0.3	1.0 0.2-3.2 8	1.7 0.0-15.2 36	1.1 0.8-1.4 3
Pomfrets Bramidae	1.6 1.4-1.8 2	16.4				0.2	
Porgies Sparidae	0.1	8.2 1.6-19.0 13	1.2 1.0-1.6 3	0.3 0.3-0.4 3	0.0	0.3 0.1-0.4 9	
Prawns Mixed species	77.2 0.1-110.3 14	51.6 9.5-135.0 35				0.3 0.1-1.0 9	
Puffers Tetraodontidae		6.0					
Rabbitfishes Seganoidae		4.9 4.9-5.0 2					
Rays, eagle Myliobatidae	0.7	53.0	1.8			0.3	
Rays, electric Torpedinidae	3.5	57.0	57.0				
Rays, sting Dasybatidae		21.8 5.0-61.5 4					
Sablefishes Anoplopomatidae	1.2	12.0		0.5 0.4-0.6 3		0.1	0.1
Salmons, Australian Arripiddae	0.1 0.0-0.1 3	10.0 10.0-10.0 3					
Sandfishes Trichodontidae		15.0					
Sauries Scomberesocidae		22.6 8.0-30.0 3				0.0	
Sawfishes Pristidae		12.0					

Table 1.—continued.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Scallops Pectinidae	1.6 0.1-3.1 7	19.0 10.0-30.0 4	23.3 17.0-29.5 2	0.2 0.2-0.2 2	8.3 0.0-39.0 5	0.0 0.0-0.1 5	0.0
Scombrops boops		10.0					
Scorpionfishes and Rockfishes Scorpaenidae		5.0 5.0-5.0 2	2.8	0.5 0.0-1.5 10		0.5 0.1-1.2 5	
Sculpins Cottidae							0.1 0.0-0.1 2
Sea cucumbers Mixed species	28.0	22.0 2.9-82.0 6			4.0		
Sea Robins Triglidae				1.2			
Sharks, cat Scyliorhinidae					6.1	1.3 0.7-1.9 2	
Sharks, dogfish Squalidae	1.0	13.2 11.5-15.0 2	5.2	2.6		0.8 0.4-1.2 7	0.1
Sharks, hammerhead Sphyrnidae	0.6 0.5-0.8 2	27.0 9.2-44.8 2	2.9 2.1-3.8 2			0.9 0.6-1.3 3	
Sharks, mackerel Lamnidae						1.2 0.1-2.1 3	
Sharks, requiem Carcharhinidae		19.2 8.4-45.3 13	24.6 2.8-66.0 3		0.5 0.0-1.1 3	0.7 0.1-1.5 8	
Sharks, sand tiger Odontaspididae		13.6 12.5-14.3 3			0.2		
Sharks, whale Rhincodontidae		8.0					
Sheathfishes Siluridae	.09	10.0					
Shrimps Mixed species	4.6 0.1-13.1 9	20.2 7.0-40.0 22	19.3 7.4-42.0 7	0.7 0.2-1.5 7	0.7 0.0-1.9 4	0.2 0.0-0.5 12	
Silversides Atherinidae		40.0 7.0-73.0 2					
Skates Rajidae	0.4 0.1-0.7 2	12.0 10.0-14.0 2	5.8 3.0-9.8 3	0.2	0.0	0.4 0.2-0.8 3	0.1
Sleepers Eleotridae	3.8	15.2 4.3-26.0 2			0.0		
Smelts Osmeridae	0.8	28.5 4.1-50.0 5	20.0	0.2 0.0-0.3 2	0.1	0.0 0.0-0.1 8	
Smelts, deep sea Bathylagidae						0.4	
Snails Mixed species	23.4 4.0-62.2 3	71.3 41.0-86.9 3	25.0	0.1	16.8 16.0-17.6 2		
Snake Mackerels Gempylidae	0.1	10.0		0.2	0.0		
Snappers Lutjanidae	0.7 0.0-1.6 4	22.8 4.0-75.9 8	2.3	0.3 0.3-0.3 3	0.1 0.0-0.1 2	0.4 0.3-0.6 2	

Table 1.—continued.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Snooks Centropomidae		11.2 2.7-41.3 9			0.0 0.0-0.0 2		
Soapies Leiognathidae		7.8 7.0-10.0 4					
Soles Soleidae	0.0	7.3 1.8-10.0 3	0.8	0.0		0.1 0.1-0.3 8	
Spadefishes Ephippidae	0.1	11.8 7.0-20.0 5			0.0		
Squids Mixed species	10.9 2.9-15.0 3	32.0 5.0-185.6 11	23.8 7.6-84.0 6	0.2	0.6 0.2-0.8 3	0.2 0.1-0.3 4	
Squirrelfishes Holocentridae						0.2 0.2-0.2 2	0.2
Stargazers Uranoscopidae						1.3	
Sturgeons Acipenseridae				0.6		0.1	
Suckers Catostomidae				0.0 0.0-0.0 5		0.3 0.0-1.3 13	0.3 0.2-0.4 2
Sunfishes and black basses Centrarchidae	1.4	3.4		0.0 0.0-0.1 5	0.3	0.3 0.0-0.6 21	0.5 0.1-1.1 4
Surfperches Embiotocidae				0.1 0.1-0.1 2			
Surgeonfishes Acanthuridae		5.0 4.9-5.0 2					
Swordfishes Xiphiidae		11.0				0.9 0.2-2.0 25	1.1
Tarpons Elopidae		20.9 3.5-63.0 4	7.6				
Therapons Theraponidae		33.4 5.5-86.0 6					
Threadfins Polynemidae	0.1	16.8 2.0-72.0 12			0.0		
Tilefishes Branchiostegidae		7.2 0.3-14.0 2	0.0				
Tonguefishes Cynoglossidae		12.0				0.8 0.1-2.3 3	
Topshells Trachidae	7.4 6.1-8.7 2						
Triggerfishes and filefishes Balistidae	0.2 0.0-0.6 3	7.0 1.1-10.0 3	1.5		0.0 0.0-0.0 2		
Trouts and salmons Salmonidae	1.7 0.2-4.0 21	11.8 1.5-45.0 27	10.4 1.4-26.0 8	0.5 0.0-4.6 53	0.4 0.1-0.7 7	0.5 0.0-3.3 40	0.6 0.0-1.6 5

Table 1.—continued.

	Copper	Iron	Zinc	Iodine	Manganese	Mercury	Organic mercury
				ppm			
Tunas *Euthynnus* sp.	0.5	40.0	0.2		0.2	0.3 0.2-0.4 9	
Tunas *Thunnus* sp.		27.5 2.7-80.0 9	0.8	0.3 0.2-0.4 3	0.3 0.1-0.5 2	0.5 0.1-1.4 35	0.5 0.5-0.5 2
Viperfishes Chauliodontidae	37.3	32.2 3.5-61.0 2		0.5			
Weevers Trachinidae						2.0	
Whales Mixed species						0.9 0.2-1.7 4	
Whitings Sillagonidae	0.1 0.1-0.2 3	9.8 0.9-22.0 6	7.9 0.6-21.8 4	0.9			0.1
Wolffishes Anarhichadidae				0.9		0.1	0.1
Wrasses Labridae				0.2 0.1-0.3 2			

Table 2. — Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks. III. Microelements: Lead, arsenic, fluorine, silver, cadmium, cobalt, and selenium.

	Lead	Arsenic	Fluorine	Silver	Cadmium	Cobalt	Selenium
				ppm			
Abalone Haliotidae					0.1	0.0	
Anchovies Engraulidae	0.9						
Basses, sea Serranidae		0.8 0.3-1.3 2	0.2		0.1 0.1-0.1 2	0.1	0.4
Basses, temperate Percichthyidae	0.8 0.7-0.9 2	0.4			0.0 0.0-0.0 2		0.4 0.4-0.4 2
Beardfishes Polymixiidae	0.6	0.0					
Bigeyes Priacanthidae						1.0	
Bluefishes Pomatomidae	1.6 0.1-2.3 3						
Burbots Lota	0.9						
Catfishes, freshwater Ictaluridae	0.6 0.6-0.7 2	1.2 0.1-2.2 2			0.1 0.1-0.1 3	0.0	
Chimaeras Chimaeridae		7.0					
Clams, donax Donacidae		2.6					
Clams, mactra Mactridae	4.3 1.2-7.4 2						
Clams, razor Solenidae		3.3					
Clams, softshell Myacidae	0.8	12.7					

Table 2.—continued.

	Lead	Arsenic	Fluorine	Silver	Cadmium	Cobalt	Selenium
				ppm			
Clams, Venus Veneridae	0.8 0.2-2.6 6	2.0 0.9-5.6 8			0.2 0.0-0.6 11	0.3	0.6
Cockles Cardiidae		9.8 2.1-17.6 2				0.4	
Cod, Atlantic *Gadus morhua*	0.3 0.2-0.3 3	2.1 0.9-3.4 3			0.0 0.0-0.1 3		0.8 0.4-1.2 2
Cods *Gadus* sp.		0.6 0.5-0.6 2	3.4 0.7-7.0 3	0.0	0.2 0.1-0.2 2	0.6 0.0-1.2 2	0.4
Codfishes Gadidae	0.5 0.2-1.6 10	2.3 0.3-5.8 11	3.8 0.7-7.0 4	0.0 0.0-0.0 3	0.1 0.0-0.5 13	0.3 0.0-1.2 4	0.7 0.4-1.2 3
Crabs Mixed species	0.5 0.3-0.8 5	12.2 3.8-35.6 8			3.6 0.0-22.4 13	0.0	
Crayfishes Mixed species	1.6 0.3-11.6 9	12.8 0.4-44.5 8		0.3	0.1 0.0-0.2 9	1.5 0.1-2.8 2	0.7
Cusk eels and brotulas Ophidiidae	0.2	0.6					
Cutlassfishes and hairtails Trichiuridae				0.0			
Cuttlefishes Mixed species		8.2					
Drums Sciaenidae	0.3 0.1-0.4 2	2.0 0.0-8.9 5					
Eels, conger Congridae		0.2		0.0	0.1		
Eels, freshwater Anguillidae		0.4 0.3-0.6 2			0.0		
Eels, snake Ophichthidae		0.2 0.2-0.3 2			0.1 0.0-0.1 2		
Featherbacks Notopteridae			0.5				
Flounders Pleuronectidae	0.4 0.2-0.5 3	2.5 0.1-4.5 5	0.4	0.0 0.0-0.0 2	0.0 0.0-0.0 3	0.8 0.5-1.2 2	0.7 0.3-1.4 3
Gars Lepisoteidae		0.4		0.0			
Gobies Gobiidae				0.0			
Greenlings Hexagrammidae		0.4 0.3-0.6					
Grenadiers Macrouridae				0.0			
Grunts Pomadasyidae		0.0					
Guitarfishes Rhinobatidae		3.0			0.1		
Haddock *Melanogrammus aeglefinnus*	0.3 0.2-0.5 3	2.6 0.6-4.5 2	5.1		0.1 0.0-0.1 3	0.2	
Hakes *Merluccius* sp.	0.4 0.4-0.5 2				0.0 0.0-0.1 2		
Herrings Clupeidae					0.1		

Table 2.—continued.

	Lead	Arsenic	Fluorine	Silver	Cadmium	Cobalt	Selenium
				ppm			
Jacks and pompanos Carangidae	0.4	0.2 0.0-0.5 2			0.0	0.0 0.0-0.0 2	
Mackerels *Scomber* sp.			1.5				
Mackerels *Scomberomorus* sp.		0.4			0.1		
Mackerels and tunas Scombridae		0.4 0.3-0.6 3	1.5	0.0			
Minnows and carps Cyprinidae		0.6			0.1 0.0-0.1 2	0.0	
Mullets Mugilidae	6.0	4.1 0.3-8.0 2	3.0 1.1-4.9 2		0.1 0.0-0.1 2		
Mussels Mytilidae	1.1 0.1-2.4 4	29.7 1.7-63.0 5			0.7 0.2-1.9 4	0.1	
Octopuses Mixed species		8.1 1.6-14.5 2			0.0	0.1	
Oysters Ostreidae	24.9 0.2-100.0 12	9.1 0.5-42.7 10	1.1 0.7-1.6 2			0.2	0.7
Perches Percidae	0.6 0.5-0.6 2	0.3 0.1-0.6 2	0.7		0.6 0.0-1.2 4		0.3
Periwinkles Littorinidae	1.5	22.0					
Pikes Esocidae	0.6 0.5-0.9 4	0.1 0.1-0.1 2					0.2 0.2-0.4 3
Porgies Sparidae		0.5					
Prawns Mixed species		21.6 1.3-55.8 3					
Rays, eagle Myliobatidae		1.3					
Sablefishes Anoplopomatidae			0.0				
Sauries Scomberesocidae						0.6	
Scallops Pectinidae	0.3 0.2-0.5 6	8.8 0.4-33.6 7			2.8 0.0-10.6 5	2.3	
Scorpionfishes and rockfishes Scorpaenidae	1.5 1.2-1.7 2	0.5 0.3-1.3 6	0.9 0.2-1.5 2		0.2 0.1-0.3 2		
Sharks, cow Hexanchidae		4.1 3.2-4.6 3					
Sharks, dogfish Squalidae		2.7 0.6-4.3 3	5.3		0.2 0.2-0.3 2		
Sharks, hammerhead Sphyrnidae		2.1 0.6-3.6 2			0.1 0.0-0.1 2		
Sharks, requiem Carcharinidae		0.9 0.3-1.6 2			0.3 0.0-0.6 2		

Table 2.—continued.

	Lead	Arsenic	Fluorine	Silver	Cadmium	Cobalt	Selenium
				ppm			
Shrimps Mixed species	0.5 0.4-0.5 4	8.7 1.8-29.8 8			0.1 0.0-0.2 8	0.2 0.1-0.4 4	1.2 0.6-1.9 2
Silversides Atherinidae		0.3 0.2-0.3 3					
Skates Rajidae		10.3 4.4-16.2 2			0.3 0.1-0.5 2		
Smelts Osmeridae	0.5	0.2			0.1		0.2
Snappers Lutjanidae	0.5	0.4			0.1		
Soles Soleidae		0.9					
Squids mixed species		1.5 0.4-2.6 3		0.1	0.1 0.1-0.1 2	0.6 0.1-1.0 2	
Sturgeons Acipenseridae	0.8				0.1 0.0-0.1 2		
Sunfishes and black basses Centrarchidae					0.0 0.0-0.0 4	3.7	0.4
Swordfishes Xiphiidae	0.2				0.0 0.0-0.0 2	0.0	
Tarpons Elopidae		3.7 0.7-6.6 2					
Trouts and salmons Salmonidae	0.5 0.2-0.9 5	0.9 0.1-2.7 8			0.0 0.0-0.1 9		0.3 0.2-0.4 2
Tunas *Euthynnus* sp.		0.3			0.1		
Whelks Mixed Species	11.1 0.1-22.0 2	18.9					
Whitings Sillagonidae		0.7			0.0	0.0	

Table 3.—Composition of the edible portion of raw (fresh or frozen) crustaceans, finfish, and mollusks: III. Microelements: Chromium, vanadium, tin, aluminum, nickel, barium, and molybdenum.

	Chromium	Vanadium	Tin	Aluminum	Nickel	Barium	Molybdenum
				ppm			
Abalones Haliotidae				111.6			
Catfishes, freshwater Ictaluridae	0.2	0.0	0.0	0.9			
Clams, softshell Myacidae	0.4		3.2				
Clams, Venus Veneridae	0.3 0.2-0.4 5			254.7	0.6		

Table 3.—continued.

	Chromium	Vanadium	Tin	Aluminum	Nickel	Barium	Molybdenum
				ppm			
Cods, Atlantic *Gadus morhua*	0.1 0.1-0.1 2						
Cods *Gadus* sp.		0.5 0.0-1.0 2	1.6 0.0-3.7 4	2.5 1.8-3.1 2			
Codfishes Gadidae	0.1 0.0-0.3 8	0.6 0.0-1.3 5	1.4 0.0-3.7 9	4.1 0.1-21.8 9	0.0 0.0-0.1 2	0.2	3.0
Crabs Mixed species	0.1 0.1-0.2 2			35.9			0.6
Crayfishes Mixed species	0.1	2.9 0.0-8.5 3	1.2 0.9-1.5 2	45.9 1.4-90.3 2	0.1 0.0-0.1 2		0.2
Cusk eels and brotulas Ophidiidae				1.8			
Cutlassfishes and hairtails Trichiruidae		0.0	0.0	1.8			
Eels, conger Congridae		0.0	0.0	2.8			
Eels, freshwater Anguillidae		0.0					
Flounders Bothidae	0.3			1.0		0.2	
Flounders Pleuronectidae	0.1 0.0-0.2 5	0.1 0.0-0.5 5	0.9 0.0-3.2 6	11.0 10.0-32.3 4			0.2 0.0-0.4 2
Gars Lepisoteidae		0.0	0.0	2.6			
Gobies Gobiidae		0.0	0.0	1.9			
Grenadiers Macrouridae		0.0	0.0	1.9			
Grunts Pomadasyidae		0.0	0.3	2.6			
Haddocks *Melanogrammus aeglefinnus*	0.1 0.0-0.3 4	0.0		1.0	0.1		0.2
Hakes *Merluccius* sp.	0.1 0.1-0.1 2		1.9	0.3 0.1-0.5 2	0.0		
Jacks and pompanos Carangidae				5.3 1.2-9.3 2			
Mackerels and tunas Scombridae		0.0 0.0-0.0 3	0.0	89.8 1.2-178.2 2			
Minnows and carps Cyprinidae		0.9 0.0-1.8 2	9.1 0.0-18.2 2	25.7 1.3-46.1 3			
Mussels Mytilidae		0.3		2.9	0.5 0.5-0.5 2		
Oysters Ostreidae	0.1 0.1-0.1 2	0.1	1.4	13.4	0.5		
Perches Percidae	0.1		0.6		0.2		
Pikes Esocidae			2.2 0.5-5.4 3		0.2 0.2-0.2 3		

Table 3.—continued.

	Chromium	Vanadium	Tin	Aluminum	Nickel	Barium	Molybdenum
				ppm			
Prawns Mixed species							0.5 0.3-0.8 5
Sablefishes Anoplopomatidae		0.0	0.0	3.1			
Sauries Scomberesocidae				1.1			
Scallops Pectinidae	0.1 0.1-0.1 5	2.1 2.1-2.1 2			0.0		
Scorpionfishes and rockfishes Scorpaenidae	0.1 0.1-0.1 2						
Sea cucumbers Mixed species				43.8			
Sharks, requiem Carcharhinidae		0.7 0.3-1.1 2		11.5 11.4-11.6 2			
Shrimps Mixed species	0.1 0.0-0.1 7	1.9			0.0		0.0
Smelts Osmeridae	0.8		12.2		0.2		
Snappers Lutjanidae	0.1						
Soles Soleidae			3.2				
Squids Mixed species			0.3	17.5 1.3-47.4 3			0.3
Swordfishes Xiphiidae					0.0		
Trouts and salmons Salmonidae	0.1 0.0-0.2 3		1.6 0.4-3.6 3	2.1 1.2-3.0 2	0.2 0.2-0.2 2		0.0
Whitings Sillagonidae		0.0			0.0		

Table 4.—References by species for microelement contents of finfish, crustaceans, and mollusks.

Abalones (Haliotidae)	6, 85, 86, 90, 106, 109, 142, 187
Anchovies (Engraulidae)	37, 41, 58, 85, 97, 106, 110, 124, 134, 154, 172, 179, 210
Argentines (Argentinidae)	224
Barracudas (Sphyraenidae)	85, 87, 90, 106, 107, 199
Basses, sea (Serranidae)	8, 21, 37, 45, 46, 47, 75, 85, 87, 106, 107, 108, 124, 142, 146, 151, 155, 172, 210, 223
Basses, temperate (Percichthyidae)	96, 114, 143, 144, 149, 206, 223, 224
Batfishes (Ogeocephalidae)	107
Beardfishes (Polymixiidae)	196
Bigeyes (Priacanthidae)	208
Billfishes (Istiophoridae)	106, 162, 198, 201
Bluefishes (Pomatomidae)	45, 58, 107, 113, 124, 150, 151, 155, 206, 223
Bombay ducks (*Harpodon nehereus*)	106, 136, 186
Bowfins (Amiidae)	96, 206
Burbots (Lota)	10, 25, 60, 96, 137, 207, 215, 218
Butterfishes (Stromateidae)	10, 41, 95, 106, 136, 186
Butterflyfishes (Chaetodontidae)	26, 85, 106, 134
Caesios (Caesionidae)	85, 106
Catfishes, airbreathing (Clariidae)	107, 134, 167, 168
Catfishes, airbreathing (Heteropneustidae)	159, 167, 169
Catfishes, freshwater (Ictaluridae)	4, 5, 24, 59, 67, 72, 88, 96, 113, 155, 159, 167, 168, 169, 171, 191, 203, 206
Catfishes, sea (Ariidae)	10, 26, 41, 85, 106, 107, 134, 136, 151, 169, 186
Cavefishes (Amblyopsidae)	168
Characins (Characidae)	87
Chimaeras (Chimaeridae)	103
Chubs, sea (Kyphosidae)	45
Cichlids (Cichlidae)	106, 107
Clams, arkshell (Arcidae)	85
Clams, donax (Donacidae)	48, 118
Clams, freshwater (mixed species)	86, 106
Clams, mactra (Mactridae)	58, 106, 178
Clams, razor (Solenidae)	58, 74, 90, 106, 109, 141, 206
Clams, softshell (Myacidae)	34, 44, 55, 130, 176
Clams, tellin (Tellinidae)	106
Clams, Venus (Veneridae)	6, 24, 25, 26, 29, 30, 44, 48, 53, 63, 76, 82, 85, 86, 90, 103, 104, 106, 108, 115, 118, 124, 142, 172, 175, 176, 177, 180, 181, 182, 183, 187, 191, 206, 210, 211

Table 4.—continued.

Cockles (Cardiidae) 20, 23, 38, 48, 58, 85, 106, 119
Cods, Atlantic (*Gadus morhua*) 13, 15, 24, 116, 133, 137, 183, 204, 224
Cods (*Gadus* sp.) 10, 13, 35, 69, 85, 90, 115, 151, 207
Codfishes (Gadidae) 8, 10, 11, 13, 19, 24, 25, 35, 44, 45, 46, 51, 67, 69, 70, 76, 85, 87, 90, 94, 100, 104, 106, 109, 112, 113, 115, 116, 121, 124, 129, 149, 150, 151, 152, 155, 156, 160, 166, 172, 178, 179, 182, 191, 194, 200, 206, 214, 215, 224
Crabs (mixed species) 23, 24, 25, 26, 32, 33, 38, 45, 51, 66, 85, 86, 90, 92, 101, 103, 104, 109, 128, 130, 135, 142, 152, 156, 161, 172, 186, 187, 191, 198, 200, 205, 206, 213, 224
Crayfishes (mixed species) 21, 22, 23, 24, 25, 28, 32, 38, 41, 45, 48, 58, 63, 67, 80, 85, 90, 104, 105, 106, 110, 113, 115, 129, 150, 155, 156, 172, 174, 175, 177, 178, 180, 181, 182, 184 , 186, 191, 194, 195, 196, 198, 207, 224
Cusk eels and brotulas (Ophidiidae) 67, 87, 115, 196
Cutlassfishes and hairtails (Trichiuridae) 2, 41, 67, 85, 106, 186
Cuttlefishes (mixed species) 20, 35, 48, 58, 147, 172, 222
Dolphins (Coryphaenidae) 106, 151, 162, 198
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MFR Paper 1324. From Marine Fisheries Review, *Vol. 40, No. 9, September 1978. Copies of this paper, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*

MFR PAPER 1325

A Trawl Design: Employing Electricity to Selectively Capture Shrimp

WILBER R. SEIDEL and JOHN W. WATSON, Jr.

ABSTRACT—A shrimp trawl designed to selectively capture shrimp and eliminate the incidental capture of bottomfish and other marine organisms is described. The purpose of this trawl is to conserve the fish presently lost during shrimp trawling. Normal shrimp trawl bycatch is eliminated by completely closing the entrance to the net with a webbing panel. Shrimp pass into the trawl through the bottom of the net which is constructed of large mesh webbing. Effective control and separation of shrimp and fish utilizes the behavioral difference of the animals when exposed to an electrical field. Shrimp are forced up through the bottom mesh of the net by the electrical field located under the net, while the fish are frightened away from the path of the net by the electricity.

INTRODUCTION

The catch per unit effort in the Gulf of Mexico industrial bottomfish fishery has steadily declined since 1975. The vast abundance of these fish in the northern Gulf of Mexico may be nearing an end. Juhl et al. (1976) reported a marked drop in the availability of bottomfish on traditional fishery grounds and hypothesized that the decline may be due to heavy fishing by shrimp vessels, which discard a large tonnage of the demersal finfish.

The latest National Marine Fisheries Service (NMFS) figures indicate that the magnitude of shrimp effort and the corresponding discard of fish is considerable. Total production of groundfish for 1976 by the commercial fisheries was 45,350 t. In 1975 the estimated discard rate by the U.S. shrimp fleet was 330,000 t (S. Drummond, Southeast Fisheries Center, Pascagoula Laboratory, Pascagoula, Miss., pers. commun.). The NMFS shrimp fleet discard survey data for 1975 shows that 15,400 t of Atlantic croaker, *Micropogon undulatus*, spot, *Leiostomus xanthurus*, and sand seatrout, *Cynoscion arenarius*, were discarded in the inshore waters (0-10 m) off Louisiana, Mississippi, and Alabama. Data collected by the Mississippi Gulf Coast Research Laboratory indicates that large numbers of juvenile Atlantic croaker, Gulf menhaden (*Brevoortia patronus*), spot, and sand seatrout present in the Mississippi Sound were greatly reduced because of intensive trawling when the shrimp season opened in June 1976.

It is apparent that the discarding of fish by the shrimp fleets causes greater than normal fish mortality, and can be a major factor contributing to the decline in the Gulf groundfish stocks. These discards will certainly contribute to a further reduction in fish stock abundance and may be particularly significant when juvenile fishes are discarded on the inshore nursery grounds.

One solution to eliminate the fishing pressure on demersal finfish by shrimp trawlers is to develop trawling gear that captures only shrimp while avoiding fish. As a conservation measure, the NMFS Harvesting Technology Group at Pascagoula, Miss., has undertaken the development of selective shrimp trawling gear to reduce the finfish harvest by the shrimp fleets in the southeastern United States.

WEBBING PANEL TYPE SEPARATOR TRAWLS

The initial effort to develop a simple and economical trawl, which would be similar to a conventional shrimp trawl, was to attempt separation using webbing panels inside the trawl to sort shrimp from fish (Seidel, 1975; Watson and McVea, 1977). Webbing panels were strategically placed in conventional shrimp trawls to use water flow through the net to force shrimp through the panels into the trawl bag. Fish were led along the panel into an escape chute, which allowed them to escape the trawl unharmed (Fig. 1). The panel separator trawl is a simple approach to the discard problem and, if successful, could easily be adopted by the shrimp industry.

The Harvesting Technology Group has been developing and evaluating webbing panel type separator trawls in the Gulf of Mexico since 1975. The development work has resulted in a separator trawl that functions relatively well under most conditions in the offshore shrimp fishery (10-30 fathoms). Comparative trawling tests between the separator and standard shrimp trawls indicate that an average 60-80 percent of the finfish captured in a standard trawl can be eliminated by a separator trawl.

A major problem with the webbing panel type separator trawl, however, is the loss of shrimp. No matter what the specific design, some portion of shrimp entering the trawl mouth will pass out the escape exit along with the finfish. Shrimp loss can vary greatly depending on conditions encountered. On the majority of offshore fishing grounds

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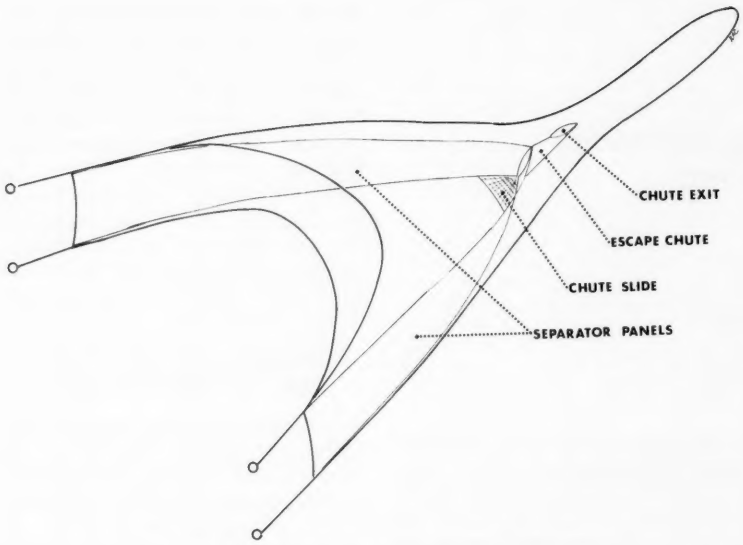

Figure 1.—Webbing panel type shrimp separator trawl design.

where most of the fish are larger and not heavily concentrated, the separator trawl shrimp catch can average as little as 10 percent less than the standard shrimp trawl. When heavy concentrations of fish are encountered (500-1,000 pounds/hour) or when the fish are small in size, the shrimp loss may reach 50-60 percent. The smaller fish also tend to gill in the separator panel and block the panel, thereby reducing the amount of shrimp that can pass through to the bag. Large concentrations of fish also cause more shrimp to be carried out the fish exit without contacting the separator panels. One other factor affecting the efficiency of the shrimp separator trawl is the towing time. As it increases, so does the rate of shrimp loss because accumulating fish clog the separator panels.

Limitations of the panel type separator trawl make general acceptance of the trawl by the commercial shrimp fleet doubtful. Results indicate good potential for limited application on many offshore shrimp grounds, but it is not likely to be universally accepted. The greatest potential destruction of groundfish stocks by shrimp trawlers occurs in the inshore shrimp fishery where fish concentrations are more dense and the fish sizes generally smaller. Under these conditions, where a shrimp separator trawl is most needed, the conventional webbing panel type separator trawl is the least efficient and would be unacceptable by shrimp fishermen. There is, therefore, an urgent need for a more effective approach to the fish discard problem, particularly by the inshore shrimp fishery, even though the solution may be more complicated and somewhat more expensive to use.

RECENT ADVANCES IN ELECTRICAL FISHING TECHNOLOGY

The Harvesting Technology Group has been involved in applying electrical fishing techniques since the mid-1960's. This work resulted in the development of an electric shrimp trawl system (Seidel, 1969). Although not widely accepted at present by the fishing industry, the electric shrimp trawl system is an effective harvesting device and can increase shrimp production day or night. Recent advances by the Harvesting Technology Group with the electric shrimp trawl system have greatly improved its capability. Improvements to the electrical pulser system, and particularly the electrode array design, have significantly improved performance. Recent behavioral studies of shrimp reactions to the electrical stimulus and field experiments with the trawl established the first known, accurately defined catch efficiency for any trawl (Watson, 1976). Further studies of fish behavior to electrical fields made possible the control of fishes by electrotaxis (Klima, 1972; Seidel and Klima, 1974). This expertise and technology, which has been established within the Harvesting Technology Group, can be utilized to develop a shrimp separator trawl system which potentially could eliminate the capture of all fish on any shrimp ground, and would certainly offer a solution to the difficult problem of separating fish and shrimp on the inshore grounds. A general concept of the trawl design follows.

SELECTIVE ELECTRIC SHRIMP TRAWL

A diagrammatic view of a selective shrimp trawl using electricity is shown in Figure 2. The most prominent and unusual feature of this concept is that the mouth of the trawl is completely closed with a webbing panel, and 6-8 feet of setback is provided to give the mouth panel a pronounced slope (Fig. 3). The fish barrier closing the mouth of the trawl is made of webbing and allows water to flow through the trawl, but prevents fish from entering the net. A large (12- to 18-inch) mesh bottom panel is placed in the net and the trawl is adjusted to fish 12-24 inches from the bottom. The electrode array is attached to the footrope of the trawl and trails back under the net to create an electrical field under the net. The electrodes are constructed of 1-inch diameter rope covered with conducting material to provide a large diameter electrode and thus increase the electrical current flow into the water. A capacitor discharge electrical pulsar, similar to that described by Seidel (1969) and Watson (1976), is used to create the electrical field, which controls the behavior of the shrimp. Shrimp are forced to jump up through the large mesh bottom panel, while fish stimulated by the field are

herded ahead of the trawl (Fig. 3). Other fish are simply directed away from the trawl by the closed mouth. This approach is unique and differs from other separator trawl designs in that the fish never enter the trawl; therefore, they do not have to be separated from the shrimp catch. The application of electricity to sort shrimp from fish is possible because of the differences in behavioral reactions of fish and shrimp to an electrical field.

Klima (1968) studied the reaction of penaeid shrimp to electrical fields. He found that the optimum voltage level and pulse rate needed to induce a "jumping" reaction (Watson, 1976) in shrimp was 3.0 V (measured across 10 cm distance parallel to the electric field) at a pulse rate of 4-5 pulses per second. To induce electrotaxis in fish, pulse rates of 15-50 per second at voltage levels of 1.5-3.0 V across 10 cm are required (Klima, 1972; Seidel and Klima, 1974). The slower pulse rates required to control the shrimp do not induce electrotaxis in fish, but produce a fright response instead. In addition, the reaction direction of shrimp to the electric field is vertical while the fright reaction of fish is horizontal or 90° different from the shrimp's movement. These factors, together with optimizing the electric field, will effectively select shrimp for capture and at the same time drive fish away from the electrified area under the trawl.

The electrical separator trawl concept is technically feasible and represents a very effective approach to solving the shrimp fleet discard problem. The use of an electrical field provides direct control of the shrimp and fish rather than relying on their passive behavior as with panel type separator trawls. The technology and expertise exist to accomplish the development and introduction of this selective shrimp trawl into the shrimp fishing industry, and would greatly enhance the capability for the effective conservation and management of our shrimp and fish resources.

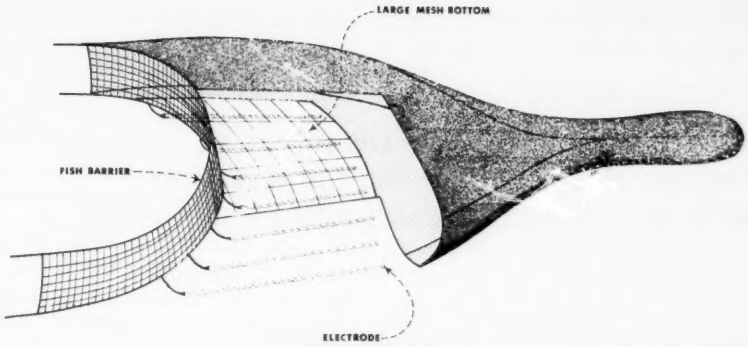

Figure 2.—Selective electric shrimp trawl design showing placement of large mesh bottom entrance, fish barrier, and electrodes.

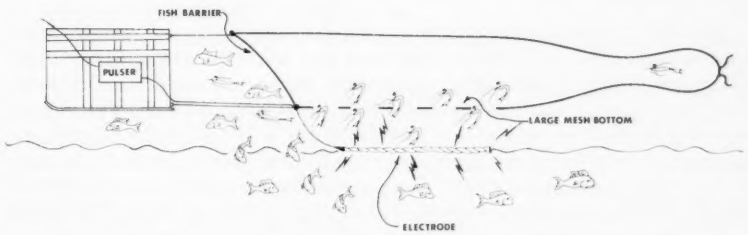

Figure 3.—Selective electric trawl diagram depicting method of shrimp separation employing an electrical field.

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MFR PAPER 1326

Use of Carbon Dioxide Dissolved in Refrigerated Brine for the Preservation of Pink Shrimp (*Pandalus* spp.)

HAROLD J. BARNETT, RICHARD W. NELSON,
PATRICK J. HUNTER, and HERMAN GRONINGER

ABSTRACT—The need to travel farther to productive fishing grounds has made it increasingly difficult for Pacific Northwest and Alaska fishermen to land iced, whole pink shrimp of high quality. Comparative studies were conducted to determine the effectiveness of holding pink shrimp in ice, untreated refrigerated brine, and refrigerated brine treated with carbon dioxide as a means of increasing the keeping quality of the landed shrimp. Holding the shrimp in the brine-CO_2 mixture inhibited bacterial and enzymatic changes causing spoilage and extended the keeping quality of the shrimp from 3 to 4 days in ice to 6 days or more in the treated brine. Recommendations are made for additional studies prior to commercial applications.

INTRODUCTION

The pink shrimp (*Pandalus* spp.) fishery makes an important contribution to the volume and value of the fisheries of the Pacific coast and Alaska. Annual catches in recent years have exceeded 130 million pounds (Pacific Packers Report, 1977) and values in excess of $15 million ex-vessel.

The north Pacific pink shrimp are small, from 80 to 120 whole shrimp per pound commonly, and are usually stored whole in ice aboard the fishing vessel (Fig. 1). Because they spoil easily, the shrimp must be delivered to the processing plant within 3-4 days after harvesting. However, because of the rapid growth in the shrimp industry since the late 1950's, fishing grounds located near processing ports are no longer as productive as they once were. As a result catch quotas have been established for many areas to prevent depletion of stocks, and vessels frequently travel farther to fish, making it increasingly more difficult to bring in full loads of acceptable quality shrimp. The time limit of 4 days in iced storage therefore becomes a controlling factor in expanding the fishing areas. Thus, there is a need for methods of preservation that permit the retention of quality during longer periods of storage on the vessel.

Existing information describing tests to preserve pink shrimp in refrigerated seawater (RSW) indicates that the technique gives good results (Roach and Harrison, 1954; Stern, 1958; Collins, 1960a; Seagran et al., 1960; and Idyll et al.[1]); nevertheless, it has never been consistently satisfactory on a commercial scale. Some failures can be attributed to poorly engineered and misused systems, but allowing for variation in commercial applications, RSW-held shrimp are usually no better in quality than iced shrimp held for the same period.

In studies to improve the RSW method (Barnett et al., 1971), we found

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[1]Idyll, C. P., J. B. Higman, and J. B. Siebenaler. 1952. Experiments on the holding of fresh shrimp in refrigerated seawater. Processed Report, ML 2738, 23 p. Fla. State Board Conserv.

Figure 1.—A typical north Pacific shrimp boat.

that CO_2 gas dissolved in chilled brine effectively retarded the growth of spoilage bacteria on whole fish. Carbon dioxide has been experimentally used before to preserve finfish and pink shrimp (Coyne, 1932, 1933; Hjorth-Hansen, 1933; Stansby and Griffiths, 1935; Makashev, 1954); however, except for a study (Anonymous, 1968) conducted by the Fiskerministeriets Forsøgabortorium, the research has been confined mainly to the effectiveness of storage in controlled gaseous atmosphere. Because the results of our tests in preserving fish in the CO_2-refrigerated brine were so promising, experiments were initiated to determine the effectiveness of the technique applied to pink shrimp. The study described here is concerned with the storage life, quality, and composition of pink shrimp held in refrigerated brine containing dissolved CO_2.

REFRIGERATED BRINE EQUIPMENT

Although the use of CO_2 in brine has favorable results with respect to increased storage life of both fish and the brine, the addition of CO_2 has undesirable side effects such as the acceleration of corrosion rates of metals coming into contact with the acidified brine. For example, NaCl brine saturated with CO_2 is moderately acid and highly corrosive (Barnett et al., 1971). To lessen the occurrence of corrosion in our shrimp experiments in the laboratory, we used the equipment described in the initial publication. This consisted of two fiberglass, insulated, 55-gallon, epoxy-coated drums and a brine chiller (Fig. 2). Polyethylene liners were suspended in the drums to prevent the shrimp from freezing to the sides of the drums. Rotary-type circulating pumps were used for recirculating chilled brine (a solution containing 3.0 percent NaCl and comparable to RSW)[2]. Carbon dioxide gas was fed through a ¼-inch Tygon[3] hose into the suction side of one of the pumps for maximum diffusion.

[2]Sodium chloride brine was used in lieu of natural seawater because clean seawater was not conveniently available to the laboratory. This technique had been used by others (Collins, 1960b; Seagran et al., 1960; Davis and Clark, 1944) and found to give good results. In comparative experiments, Roach and Harrison (1954) demonstrated that fish held in refrigerated brine were of equal quality to fish held in RSW. The term RSW is therefore frequently used to refer to either the seawater or 3.0 percent salt brine media.

Figure 2.—Brine chiller unit for shrimp-holding experiment. Refrigeration unit is at left. Epoxy-lined holding tanks with plastic cooling coils used to chill the tanks are being covered with insulation.

EXPERIMENTS AND OBSERVATIONS ON STORAGE LIFE AND QUALITY

The shrimp (*Pandalus jordani*) used for the experiment were caught in a trawl off the coast of Oregon. In preparing the samples, 375 pounds of shrimp caught about 24 hours before were divided into three equal lots. One lot was iced in a plastic bin and held in a refrigerated room at 34°F. The other two lots were placed in the polyethylene-lined drums at a shrimp-to-brine ratio as close to 1:1 (weight/weight) as possible.

One tank of brine had been treated with CO_2 gas before the shrimp were loaded into it. The gas was fed into the brine continuously throughout the experiment at a rate of 0.2 foot^3/hour. The second tank of brine was not treated with CO_2. The temperature of the brine in both tanks was maintained at 30 ±0.5°F.

Periodically, shrimp from three stored lots and a sample of brine from each of the brine storage experiments were removed for examination.

Criteria used for evaluation included sensory attributes, chemical and physical changes, and bacteria counts of shrimp held in RSW modified with CO_2, RSW, and in ice.

Bacteriological Measurements

Total bacterial plate counts were made on the shrimp by the methods described by Pelroy and Eklund (1966). Briefly, the method is as follows: 45 g of headed shrimp (shells on) were homogenized aseptically with 180 ml of sterile 0.1 percent peptone solution at 3.8°F. Serial dilutions in 0.1 percent peptone-water were prepared for pour plates from the homogenate.

Total plate counts were made by use of TPY solution (1.5 percent trypticase, 0.5 percent peptone, 0.5 percent yeast extract, 0.2 percent glucose, 0.5 percent

[3]Reference to trade names does not imply endorsement by the National Marine Fisheres Service, NOAA.

Table 1.—Microbiological and chemical changes occurring in ice, untreated refrigerated brine, CO_2-treated refrigerated brine, and in the flesh of shrimp held in these brines.

Storage time (Days)	Data on icing: CO_2 conc. flesh (ppm)	pH flesh	Total bacterial counts flesh (No./g)	Salt conc. flesh (%)	Data on refrigerated brine without CO_2: CO_2 conc. flesh (ppm)	CO_2 conc. brine (ppm)	pH flesh	pH brine	Total bacterial counts flesh (No./g)	Total bacterial counts brine (No./ml)	Salt conc. flesh (%)	Data on refrigerated brine with CO_2: CO_2 conc. flesh (ppm)	CO_2 conc. brine (ppm)	pH flesh	pH brine	Total bacterial counts flesh (No./g)	Total bacterial counts brine (brine)	Salt conc. flesh (%)
0	1,364	7.4	3.4×10^5	0.5	1,364	462	7.4	7.0	3.4×10^5	—	0.5	1,364	2,552	7.4	4.3	3.4×10^5	—	0.5
1								7.5	1.9×10^4	1.3×10^5					6.3	9.6×10^4	6.5×10^4	
2	—	8.0	1.6×10^6	0.4	482	—	8.3	7.7	5.5×10^5	—	2.1	2,900	5,300	7.2	6.4	8.0×10^5	—	2.0
3																		
4									2.3×10^5	1.8×10^5						2.1×10^5	1.1×10^5	
5	1,012	8.2	1.6×10^8	0	790	1,190	8.2	7.8	3.8×10^7	4.0×10^6	2.1	4,600	5,650			1.2×10^5	1.1×10^5	2.2
6																		
7														7.1	6.5	2.8×10^5	2.0×10^5	2.4

NaCl, and 1.5 percent agar). Counts were made on the brines by taking 1-ml samples, making appropriate serial dilutions in 0.1 percent peptone-water mixture, and plating out into the TPY medium. The plates were incubated at 22 °C for 5 days. Table 1 shows the results for total bacterial plate count analysis on the shrimp and brine samples.

Bacterial counts of the shrimp held in ice increased from 10^5 to 10^6 organisms/gram during the first 2 days of the experiment. A count of 10^6 organisms/gram usually indicates spoilage. At this time, the shrimp had been out of the water about 3 days and showed some loss of color and a slight off-odor. Although no bacterial counts were made between the second and fifth days of the test, the iced shrimp were judged subjectively to be spoiled on the fourth day of the experiment (Table 2). By the fifth day of storage, the iced shrimp were putrid. Total plate counts had risen to 1.6×10^8 organisms/gram.

Bacterial counts decreased in the shrimp held in the untreated brine (Table 1) during the initial stages of storage, probably due to a washing and diluting effect of the brine. The shrimp had an off-odor suggestive of incipient spoilage by the fourth day, although plate counts were below 10^6 organisms/gram at the time. The fewer numbers of bacteria found in both the shrimp and the brine compared with shrimp in ice was due in part to the lower storage temperature and probably also selective bacterial growth patterns that may occur in the nearly anaerobic environment of the brine (Shewan, 1964). A sharp increase in bacteria count was observed on the fifth day of the test corroborating the organoleptic findings that the shrimp were spoiled (Table 2).

Table 2.—Sensory evaluations of shrimp held in ice, untreated refrigerated brine, and CO_2-treated refrigerated brine.

Storage time (Days)[1]	Overall sensory scores on cooked shrimp samples: Ice	Brine	Brine+CO_2	General comments on raw and cooked shrimp samples: Ice	Brine	Brine+CO_2
0	[2]9.0	9.0	9.0	Excellent quality	Excellent quality	Excellent quality
2	7.5	7.8	8.3	Good color, odor but some loss of flavor	Good color, odor but some loss of flavor; slightly salty	Good color, odor, and flavor; slightly salty
3	7.0	6.7	7.5	Slight-moderate, loss of color, moderate off-odor, bland flavor soft texture	Slight loss of color, bland flavor, soft texture, slightly salty	Good color, odor, and flavor, slightly salty, firm texture
4	4.0	—	—	Unacceptable, moderate loss of color, strong spoilage odor, poor flavor, soft texture	Pale color, slight spoilage odor	Good color and odor
5	[3]	4.0	—	—	Unacceptable. Strong spoilage odor, poor flavor, soft texture	Good color and odor
6	[3]	[3]	6.7	—	—	Good color, odor, and flavor. Slightly tough, salty.

[1] Storage time given is the number of days held at the laboratory. The shrimp was held iced approximately 24 hours aboard the fishing vessel before delivery.
[2] A score of 10 denotes a product of highest quality; one of 5 denotes a product of borderline quality.
[3] Too spoiled to taste.

Bacterial counts of the shrimp held in the modified brine (Table 1) were also reduced initially by the dilution effect of the brine. There was an increase in bacteria in the shrimp after 2 days of storage but counts in both the shrimp and brine remained below the level considered to be indicative of spoilage for the remainder of the experiment.

Chemical Measurements

pH

A Beckman combination electrode was used to measure the pH of the shrimp flesh and brines. The shrimp was prepared for analysis by homogenizing a 2:1 mixture by weight of distilled water and raw shrimp flesh. The pH values of the brines are given in Table 1. Almost without exception, the pH of the flesh of the shrimp held in ice and in untreated brine increased during storage. These changes occurred simultaneously with increases in microbial populations in both flesh and brine samples. The pH increase in both the shrimp and the brine was probably due to ammonia from the growth of bacteria.

In the case of CO_2-treated brine, there was an initial and rapid increase in pH from 4.3 to 6.3. This is attributed to buffering by proteins and other soluble components from the shrimp. The initial pH measurement was made before the shrimp came into contact with the brine. The pH of the brine was reasonably constant at about 6.4 after that time. The pH of the flesh of the shrimp held in

the modified brine dropped slightly during the experiment but remained within the normal pH range of good quality shrimp. Although tests for ammonia were not made, the good quality and the lower pH of the shrimp throughout the 7 days of storage indicated that little or no ammonia was formed.

CO_2 Concentration

Analyses for CO_2 content in the flesh and brines were carried out as previously described by Barnett et al. (1971). Test results showed (Table 1) that relatively high levels of CO_2 as bicarbonate existed in the meat of the fresh raw shrimp. The concentration of CO_2 in the flesh appeared to remain relatively constant in the flesh during iced storage. The shrimp held in the untreated brine showed a reduction in the concentration of CO_2 in the flesh during storage. A significant increase in CO_2 content of the brine accompanied the general decrease of CO_2 in the flesh. The change suggests that the increase in CO_2 was contributed by protein and metabolic products dissolved from the shrimp.

The flesh of the shrimp held in modified brine contained considerably more CO_2 than did the flesh of the iced and brine-held shrimp. The modified brine, of course, contained a high concentration of CO_2 throughout the holding period.

It is apparent that the high concentrations of CO_2 in the flesh and brine inhibited microbial growth sufficiently to extend the storage life of the shrimp. Similar observations were made by Makashev (1954) and King and Nagel (1967).

Salt Concentration

The concentration of sodium chloride was measured by the methods described in Horwitz (1960). Results are shown in Table 1. The salt content of the iced shrimp was 0.5 percent initially and decreased to zero during 5 days of storage. The maximum concentration of salt in the flesh of the shrimp held in untreated brine was 2.1 percent. This concentration was reached by the second day of storage, after which there was no change. The absorption of salt in the flesh of the shrimp held in the modified brine was closely comparable. The ultimate concentration of salt in the flesh of the CO_2-brine-held shrimp was 2.4 percent. This was reached after 7 days of storage. Similar findings were made by Collins (1960a, 1961) in detailed studies to determine the changes that occur in pink shrimp held in ice and in refrigerated brine storage. He also observed in the study that water, ash, and solids contents in the system changed as a function of time causing both the raw and cooked meats to lose considerable solids.

Sensory Evaluation

Samples of shrimp from each variable in the experiment were examined at intervals to evaluate sensory changes. Samples of each were evaluated both raw and cooked.

Raw Shrimp

During the first 3 days of storage, the raw shrimp from each of the storage experiments were considered to be of acceptable quality. During this time, however, significant changes were observed in the quality of both iced- and untreated-brine-held shrimp. These were in the form of loss of natural odors and pink color. No significant loss of color or development of off-odors was detected in the shrimp held in the CO_2-treated brine. By the fourth day of the experiment, iced shrimp displayed strong ammoniacal odors indicative of microbial spoilage. They were judged to be spoiled at this time. After 5 days of storage, a pronounced sour odor existed in the untreated brine and shrimp. By this time, the shrimp had lost all their natural color and were totally unacceptable. The brine was brown-black in color, the result of what appeared to be an enzymatic reaction.

After 6 days, the shrimp held in the CO_2-modified brine retained much of their natural pink color and were essentially odorless. There were no off-odors in the brine which was light pink in color. The high concentration of CO_2 clearly inhibited the enzymatic changes causing the discoloration of the shrimp and brine when no CO_2 was added.

Cooked Shrimp

The shrimp from each experimental storage condition were prepared for taste panel evaluation by cooking in boiling brine containing 3.0 percent NaCl by weight for 3 minutes. They were then cooled in running tap water. For the purpose of tasting, the brine-held shrimp were cooled slightly longer than the iced shrimp to remove excess salt. The cooked samples were evaluated for appearance, odor, flavor, texture, and overall quality using a 10-point numerical scale. Results are given in Table 2.

The data show that the iced shrimp declined quite rapidly in quality and were unacceptable on the fourth day of storage. Similarly, the shrimp held in the untreated brine declined in quality and were judged by the taste panel to be unacceptable by the fifth day. Although the overall quality of the shrimp held in the modified brine decreased during the experiment, the product was considered to be organoleptically acceptable after 6 days of storage. Except for a slightly tougher texture and somewhat salty flavor, the product was comparable to the quality of shrimp held in ice for 2 or 3 days.

SUMMARY AND RECOMMENDATIONS

Storing north Pacific pink shrimp at 30 °F in refrigerated brine treated with CO_2 doubled the storage life of the shrimp to 6 days or more compared with 3-4 days for the shrimp held in ice. The effect of the dissolved CO_2 was to slow the rate of growth of spoilage bacteria and was caused apparently both by the lower pH of the brine and a specific inhibition by the CO_2. A black discoloration was evident in the head and gut of shrimp after 2 or 3 days of iced storage and in both the brine and shrimp after 5 days when no CO_2 was added. This discoloration is attributed to an enzymatic reaction. The shrimp and CO_2-treated brine showed no discoloration after 6 days indicating effective inhibition of the enzymatic reaction by dissolved CO_2.

The modified seawater technique should be considered for commercial

use; however, it is recommended that additional experimental investigations be conducted to determine what effect holding pink shrimp in modified brine has on machine peeling characteristics, yield, and the acceptability and quality of both the frozen and canned products.

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MFR PAPER 1327

Status and Problems of the American Shrimp Industry

ROGER W. HUTCHINSON

ABSTRACT—The shrimp industry of the United States enjoyed 2 successful years in 1976 and 1977 and expectations are that 1978 will also prove to be successful. This account gives the current status of the U.S. shrimp industry plus a brief description of various problems facing it.

INTRODUCTION

The status and problems of the American shrimp industry can be viewed in terms of two major factors influencing this industry: resource availability and market demand.

Shrimp resources are influenced by their natural environment. Favorable environmental conditions can lead to an abundance of shrimp, a good harvest, and, generally, good economic conditions in the industry. Unfavorable environmental conditions lead to a low abundance and poor industry performance. So far as the natural environment is concerned, there is nothing that the industry can do either to promote a good harvest or offset a poor harvest.

Added to this influence, the strong demand for shrimp has gradually pushed prices to the point that shrimp are labeled as a luxury food. Shrimp are not regarded as a staple in the diet and, because of this, demand for shrimp is heavily influenced by changes in population, disposable income, and product quality.

In light of these influences, it follows that the shrimp industry will be successful and have few problems when the harvest is good and markets are strong. Conversely, problems multiply with low harvests and poor markets. Shrimp fishermen have no control over factors affecting resource availability or market demand, the former being influenced by habitat conditions and the latter being influenced by national economic conditions.

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CURRENT STATUS

Going into 1978, the status of the shrimp fishing industry was excellent. Domestic landings of shrimp in 1976 and 1977 were at record levels with the total value of these landings to the fishermen reaching $331 million in 1976 and $355 million in 1977. This was a significant improvement over the $179 million in revenues in 1974. At the same time, the market for shrimp has been strong. One indicator of this strength is the wholesale price. Wholesale prices rose from an average $2.00 per pound in 1974 to $3.54 in 1976 before dropping to $3.37 in 1977, following record landings from the Gulf of Mexico.

It is too early to tell if landings of shrimp will continue high in 1978, since the major Gulf season is just beginning as this paper was written. At this time, there are no indications that landings will drop significantly. Markets for shrimp are expected to continue strong and, with good landings, should contribute to another successful year for the American shrimp industry.

PROBLEMS

The American shrimp industry consists of several, separate sectors: Harvesting, processing, importing-exporting, and domestic distribution. Because of this diversity, it is difficult to generalize about problems. For example, what may be a potential problem for fishermen may not create problems for processors or wholesalers. The problems that we have found and which are most often cited by industry members involve the harvesting sector. This sector is directly dependent on domestic shrimp resources and domestic market demand, and is sensitive to price changes. Those segments of the industry not totally dependent on domestic shrimp resources have a greater degree of flexibility in the market, allowing them to adjust to changing prices more easily. Because of this, the problems of the American shrimp industry are often associated with the harvesting sector.

In the shrimp industry, as in all industries, problems center around those factors which affect profitability. Firms in the shrimp industry require a price that allows them to be competitive in the market and earn a profit. In any case where problems do occur, the severity of the problems will be directly related to domestic resource availability, market demand, or both.

The major problems facing the shrimp industry relate to the harvesting sector and were found to be: High and rising operating costs, overcapitalization, imports, rising insurance rates, and extended jurisdiction declarations by foreign countries.

Operating Costs

Vessel operating costs have risen sharply over the past few years and continue to climb, in part because of increases in prices paid for fuel, maintenance, and supplies, such as netting. Operating costs are incurred daily and are highly visible. With rising costs, vessel operators need higher revenues to cover these costs. The major influence on vessel revenue is the availability of shrimp. A high abundance of shrimp enables the fisherman to catch a greater quantity of shrimp, and a good market allows them to receive a favorable price for their catch, producing high total revenue. When the abundance of shrimp is high, shrimp fishermen are often able to operate profitably even with significant price declines. On the other hand, if the abundance is low, it may not be profitable to operate even with significant price increases. This is because the low abundance both reduces vessel catch and increases the time spent fishing, causing operating costs per pound of shrimp to increase, offsetting higher shrimp prices. Operating costs represent a problem that becomes more severe when shrimp resources decline or when shrimp resources decline in combination with prices.

Overcapitalization

Despite some cyclical downturns, the Gulf and South Atlantic shrimp fishery has generally been perceived as being among the largest and most profitable of U.S. fisheries. This has led directly to high investment in these fisheries—an influx of new, more powerful vessels—because conditions of entry are not restrictive. Even though costs of vessels have risen (to about $250,000 currently), financing has been available. Furthermore, the regulations, the depressed resource conditions, and other problems facing some other major American fisheries have not plagued the Gulf and South Atlantic shrimp fishery. The resources, however, are limited. The net effect is that catch per vessel declines over time as more vessels enter the fishery and the risk of income loss increases. Although the industry recognizes the problem, it is not easily visualized. This is because there are a large number of independent vessel operators, and the catch on a given trip can vary with current availability of shrimp on the fishing grounds, skills of the captain, weather, and other factors.

The problem is not entirely one of generally declining profit margins as additional vessels enter this fishery. Because shrimp resources are limited and the abundance of shrimp varies from year to year, all vessels become more vulnerable to substantial losses in years when shrimp abundance is low as the total number of vessels increases. This is a risk that must be assumed by any vessel operator entering this fishery, but new vessels entering the fishery increase the risks for all those already in the fishery.

Imports

Shrimp imported into the United States increase the supply on the market and act as a restraining factor on prices. During seasonal and cyclical downturns, which are normal occurrences, some segments of the industry may cite imports as a cause for low or declining prices.

Ex-vessel price fluctuations are, however, more properly associated with variations in resource availability and market demand. Imports of shrimp can only influence prices that are low by retarding a recovery or by extending a declining trend that is already in evidence. There is no evidence to the effect that imports are the primary, leading force in seasonal and cyclical downturns in shrimp prices. Without imports, price fluctuations would continue.

The industry recognizes that the shrimp resources of the United States are limited and are not capable of providing the total quantity of shrimp that is demanded—imports accounted for 55 percent of consumption in 1977. In addition, the wide variability in domestic landings would make it impossible for processors and wholesalers to maintain and service their markets if alternate sources of supply did not exist. Imports of shrimp are a necessary source of supply although their presence on the market does result in lower average prices than would exist if imports were not available.

In years of high shrimp landings, high imports can cause prices to decline further than normal and remain down longer than normal. This is particularly critical when markets for shrimp are poor and imports of shrimp either depress prices or prevent a recovery in prices. It has been suggested that quotas or tariffs be applied to imports of shrimp to offset these occurrences. Quotas would limit total supplies of shrimp in the United States, causing prices—already in the luxury food category—to increase. Increased prices would make the domestic shrimp fisheries more profitable in the short run; in the long run, overcapitalization would become more serious, with an increase in the risk of substantial income losses in vessel operations.

The major influence of imports is felt at those times when markets decline. The industry has indicated that adequate knowledge on foreign markets is not available which can give the domestic industry, as well as importers, an indication of landings trends in other countries, processing volume, and the strength of buying by other importing countries, notably Japan.

As a result, the domestic industry often becomes aware of this influence only after the shrimp have entered the United States and begun to affect markets. This does not give them the oppor-

tunity to react to significant changes in market direction until the market has actually changed. If sufficient knowledge on trends in other shrimp producing countries were available, the domestic shrimp industry could possibly compensate for these trends in its planning. The lack of such knowledge is viewed as a major problem by some industry members.

Insurance Rates

Vessel operators have been faced with significant increases in premiums for property and indemnity insurance. Premiums for hull insurance are also expected to increase in the future. Insurance is essentially a fixed cost for the operator and must be covered through higher revenues per vessel.

Extended Jurisdictions

Mexico and Brazil are phasing out foreign fishing operations in their waters while other countries in South America are putting restrictions on the number of vessels allowed to fish in their waters. United States shrimp vessels which had operated in these areas are now expected to return to U.S. waters thus adding to the overcapitalization problem.

CONCLUSION

High landings and strong markets have contributed to 2 very good years for the American shrimp industry. The problems that exist, particularly in the harvesting sector, have been less evident because of this. As a rule, these problems are more significant in those sectors of the industry which have developed the greatest dependence on domestic resources. This would include fishermen as well as processors and wholesalers. Among those with the greatest dependence on domestic shrimp resources, these problems can be especially severe to those less able to sustain substantial losses.

MFR Paper 1327. From Marine Fisheries Review, *Vol. 40, No. 9, September 1978. Copies of this paper, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*

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NOAA Announces Marine Research Projects

A variety of undersea scientific projects, all involving submersible research vehicles and concerned with such matters as ocean floor pollution, cosmic radiation, and land slides along the continental shelf, have been scheduled by the National Oceanic and Atmospheric Administration (NOAA) for the oceans around the United States during summer and fall 1978.

Richard A. Frank, NOAA Admimistrator, said the Commerce Department agency is sponsoring investigations under the sea along parts of the Atlantic Coast, off Alaska, and in the Grand Bahamas.

The DSRV (Deep Submergence Research Vehicle) *Alvin*, the diver lockout submersible *Johnson-Sea-Link*, and several shallow water submersibles will all be used in the investigations, Frank said.

Alexander Malahoff of NOAA is concluding a series of 10 dives in the Baltimore Canyon area of the east coast, attempting to learn what causes masses of soft sediment to slide down canyon walls or slopes, and the effect this may have upon the continental shelf oil lease areas. He is using the *Alvin* in his work.

Another project involving that submersible was scheduled for September when Richard Cooper, also of NOAA, investigates the geological and ecological features of the deeper regions of the Oceanographer submarine canyon, an area about 100 miles southeast of Cape Cod, Mass. Diving in the *Alvin* to depths of almost 6,000 feet (1,800 m), Cooper will be examining the distribution and behavior of lobsters and two types of potentially commercial crabs. *Alvin* operations are supported by the National Science Foundation and the U.S. Navy, in addition to NOAA.

A variety of shallow-water submersibles capable of operating to depths of almost 1,000 feet (300 m) will be used in research projects beginning in July with a 10-day cruise by scientists of NOAA's Atlantic Oceanographic and Meteorological Laboratories, Miami, Fla.

George L. Freeland is chief scientist of a group that will make dives on the Atlantic continental shelf edge from Block Canyon off Woods Hole, Mass., to Baltimore Canyon off Cape May, N.J. The geologists will gather information on the depth, nature, and rate of change of bottom sediments along the continental shelf break. Cruise efforts will be devoted to answering questions about water mass processes that cause rapid sediment variations between shallow and deeper energy zones.

Cooper, of NOAA's Northeast Fisheries Center, Woods Hole, Mass., complemented his deeper *Alvin* dives by leading a scientific team on a 10-day shallow-water submersible cruise in July, to continue work on the geology and ecology of the Mid-Atlantic Bight Submarine Canyons. This cruise began at Cape May and ended at Woods Hole. The submarine canyons contain numerous bottom-dwelling crustaceans—for example lobsters, jonah crabs, and red crabs—of present or potential commercial value. Information on them is required by the regional fishery management councils to make decisions about management of the species.

Scientific investigations of Alaska's southeast coast took place from 15 July through 6 August, in areas from Lisianski Inlet to Boca de Quadra Inlet. William High of the Northwest and Alaska Fisheries Center was scientific leader of the investigations, which examined four types of problems: 1) Bottom-dwelling fish communities and precious corals in deep rocky coastal areas, and the efficiency of fishing gear design and deployment; 2) ecology of fish, crab, and shrimp in relation to logged and inlogged shore areas; 3) sedentary fishing gear (traps, pots, longlines) behavior and efficiency; and

Securing the hatch and releasing the submersible *Nekton Gamma* prior to diving off Southeastern Alaska. Photographs by William High, Northwest and Alaska Fisheries Center, NMFS, NOAA, Seattle, Wash.

4) distribution, abundance, and response of king crabs to fishing gear. In addition to National Marine Fisheries Service and Sea Grant scientists, investigators from the Alaska Department of Fish and Game, University of Alaska, and University of Hawaii took part.

The *Johnson-Sea-Link* lockout submersible was scheduled for two projects under this NOAA schedule. From 26 to 30 June, N. Wogman of Battelle-Northwest and R. Jones of Harbor Branch Foundation assessed X-ray fluorescence technology for mapping trace metal pollutants on the sea floor. Measurements of the pollutant element concentrations of sediments over substantial distances of ocean floor could produce information on such concentrations in continental shelf regions, estuaries, and freshwater areas.

Finally, Peter Kotzer, of Western Washington University, and Kurt Stehling, of NOAA's Office of Ocean Engineering, were slated to use the *Johnson-Sea-Link* to retrieve a photoemulsion cosmic radiation detector previously placed on the ocean floor near Grand Bahama Island, and prepare and put in place additional detectors.

Seafood Landings Hit Record Value in 1977

The value of fish and shellfish landed by U.S. commercial fishermen during 1977 reached an all time high of more than $1.6 billion, although the amount landed was down slightly from 1976, Terry L. Leitzell, Assistant Administrator for Fisheries of the National Oceanic and Atmospheric Administration (NOAA), has announced. The total value of U.S. production of processed fishery products, edible and industrial, also rose—an 11 percent increase—to $3.9 billion, the Commerce Department official said.

U.S. fishermen landed 5.3 billion pounds at ports in the United States, Puerto Rico, and American Samoa, a 4 percent decrease in amount, but 12 percent increase in value over 1976. The decrease in landings was largely due to a drop in landings of industrial (nonedible) fish.

"Commercial landings of edible species," Leitzell said, "were about 3 billion pounds, valued at $1.4 billion. This a 5 percent increase in quantity, considerably above the average for the previous 5 years, and an 11 percent increase in value." Shrimp, tuna, crab, salmon, and flounder landings accounted for a large share of the increase.

Per capita consumption of fish in the U.S. in 1977 was 12.8 pounds per person, down slightly from the record 13 pounds in 1976.

Details of these and other preliminary data dealing with U.S. fisheries are included in "Fisheries of the United States, 1977." Single copies may be ordered from User Services Branch D822, Environmental Data Service, NOAA, Rockville, MD 20852, telephone (301) 443-8330.

The amounts and values of the 1977 fisheries and percent change from 1976.

Item	1977	Change
All fish and shellfish		
Amount (billion lb)	5.3	-4%
Value (billion $)	1.6	+12%
Edible		
Amount (billion lb)	3	-5%
Value (billion $)		
Industrial and (non-edible)		
Amount (billion lb)	2.3	-11%
Value (million $)	111	+25%

The 1977 top 10 ports[1] commercial landings in millions of pounds and value in millions in terms of dollars.

Port	Landings
San Pedro, Calif.	519.5
Cameron, La.	306.7
Pascagoula-Moss Point, Miss.	272.2
Empire, La.	190.5
Kodiak, Alaska	179.6
Dulac-Chauvin, La.	153.7
Gloucester, Mass.	150.9
San Diego, Calif.	124.1
Beaufort-Morehead City, N.C.	100.7
Dutch Harbor, Alaska	100.5
Port	**Value**
San Pedro, Calif.	$109.1
Kodiak, Alaska	72.5
Dutch Harbor, Alaska	61.4
San Diego, Calif.	43.4
New Bedford, Mass.	43.2
Brownsville-Port Isabel, Tex.	42.0
Aransas Pass-Rockport, Tex.	39.0
Dulac-Chauvin, La.	33.1
Freeport, Tex.	26.0
Bayou LaBatre, Ala.	25.7

[1]Data for some ports are estimated and for some ports are not included to avoid disclosure of private enterprise.

Webster Heads R&D at NOAA

Ferris Webster, Associate Director for Research at the Woods Hole Oceanographic Institution, Woods Hole, Mass., has been named Assistant Administrator, Office of Research and Development, of the National Oceanic and Atmospheric Administration (NOAA). NOAA Administrator Richard A. Frank, in announcing the appointment to the newly created position, said Webster's educational and professional backgrounds highly qualify him for the responsibility of coordinating and supervising NOAA's broad research and development activities.

A native of St. Boniface, Manitoba, Webster was educated at the University of Alberta, receiving BS and MS degrees in physics, and at Massachusetts Institute of Technology (MIT) where he received his doctorate in geophysics. He has been with Woods Hole since 1959, joining the Oceanographic Institution as a Research Assistant. Appointed a Senior Scientist in 1970, Webster became Chairman of the Department of Physical Oceanography in 1971, and Associate Director for Research in 1973. From 1966 through 1968, while at Woods Hole, he also was Assistant Professor of Oceanography at MIT.

Webster has served on a number of commissions, committees, and groups, including chairing two Intergovernmental Oceanographic Commission groups. Currently he is chairman of the Ocean Sciences Board of the National Research Council and member of the Climate Research

Board. He also is Vice Chairman of the University-National Oceanographic Laboratory System, and Members' Representative to the University Corporation for Atmospheric Research.

President of the Oceanography Section of the American Geophysical Union, 1974-76, Webster also was Chairman of the Steering Committee for the National Academy of Sciences/National Research Concil's review of NOAA oceanic research and development, 1975-77.

He is the author or co-author of 20 scientific publications and former editor of several professional journals. His research interests are in time-dependent ocean currents, oceanic variability, time-series analysis, and oceanographic data processing.

U.S., France Sign *Amoco Cadiz* Research Agreement

American scientists will participate in a long-term scientific study of the ecological consequences of the *Amoco Cadiz* oil spill, under terms of an agreement signed in mid-summer at the French Embassy in Washington, D.C., by Richard A. Frank, Administrator of the Commerce Department's National Oceanic and Atmospheric Administration (NOAA), and Gerard Piketty, Director-General and President of France's National Center for the Exploitation of the Oceans (CNEXO).

The signing highlighted a mid-term review of the U.S.-French Cooperative Program in Oceanography carried out by Piketty and Frank during a visit by the new head of CNEXO to become acquainted with his American colleagues in oceanography. Immediately following the *Amoco Cadiz* spill, at the invitation of CNEXO, scientists from the United States, working with NOAA's Spilled Oil Research team, participated with French scientists in the preliminary scientific research on the short term consequences and on early clean-up efforts.

The two leaders pointed to the increased need for international cooperation in oceanic research as such problems as major oil spills become increasingly international in scope. They expressed satisfaction at the work being done under the U.S.-French program, and at the opportunities for closer collaboration provided by the new agreement.

Under that agreement, a joint CNEXO-NOAA scientific commission will be established to prepare and carry out a research plan complementary to the French scientific program, and to define and oversee the uses of a special $2,000,000 fund contributed by Amoco Transport Co., a subsidiary of Standard Oil of Indiana, and administered by NOAA. The commission will consist of five French and five U.S. delegates, with a French chairman and U.S. co-chairman. U.S. members will be scientists designated by NOAA, primarily from the academic community and research institutions.

The agreement becomes part of a joint program on marine environmental research carried out by the two nations under the U.S.-French Cooperative Program. Other projects include tests of equipment designed to reduce oil pollution at sea, remote sensing, and uses of dispersants and bacteria. In addition, the two leaders reviewed progress in the eight other areas comprising the overall program. These consist of data exchange, instrumentation, shelf and coastal sediment dynamics, aquaculture, marine pollution control, buoy technology, marine geology and geophysics, and man in the sea projects.

The U.S.-French program has been under way since 1970. Joint meetings for scientific review and planning are held at about 18-month intervals, and briefer, mid-term reviews are conducted to receive progress reports and identify any problems that may have arisen. The last scientific planning meeting was held in Bandol, France, in September 1977, and the next is scheduled for the United States early next year.

Wisconsin: First Great Lakes Coast Management Program Wins Approval

Approval of Wisconsin's Coastal Zone Management Program, and award of a grant of $1.3 million to the State to put the program into effect, have been announced by Secretary of Commerce Juanita M. Kreps. Wisconsin is the first Great Lakes State to receive Federal approval for its coastal zone management program. The Federal grant will augment nearly $500,000 in State funds for the program.

"Approval of Wisconsin's program is an important step in assuring wise management of the State's 620 miles of Great Lakes shoreline," Secretary Kreps said. "Now, for the first time, Wisconsin has a program to focus State attention upon the problems and opportunities that are unique to its lakeside."

Wisconsin's 15 coastal counties include 6.5 million acres of two of the largest bodies of freshwater in the world, Lake Superior and Lake Michigan. About 41 percent of the State's population lives in these counties.

Planning grants from the National Oceanic and Atmospheric Administration (NOAA) over the past 4 years have enabled Wisconsin to complete major planning tasks that led to program approval. Included have been inventories of the State's land and water uses, and studies of port development, energy facility siting, erosion, recreation, and public access to the shoreline.

Under the NOAA grant, State authorities will concentrate on the following objectives: 1) Streamlining the regulation process, including training personnel and providing technical and financial assistance to local governments; 2) Strengthening the role of local governments to help them manage their own coastal resources; 3) Improving urban waterfront areas and public access to those areas; 4) Increasing the public's participation in decisions affecting the Great Lakes; and 5) Identifying new opportunities and markets for Wisconsin's Great Lakes ports.

Canadian Survey Shows Sportfishing is a Big Business

Highlights of Canada's nationwide angling survey released in mid-year by Fisheries Minister Roméo LeBlanc leave no doubt that sportfishing is big business in that nation.

The survey, carried out in 1976 and covering the year 1975, reveals that 6.4 million persons of all ages went sportfishing in Canada in 1975. Of this total, 5.4 million were Canadians, and over a million were visiting anglers, primarily from the United States. Anglers under 16 and those under the legal licensing age in certain provinces made up to 1.7 million of the total, Fisheries and Environment Canada reports.

In total, anglers fished 75 million days and caught almost a quarter of a billion fish. While brook trout, perch, walleye, and northern pike topped the list of most fish landed, the agency listed several marine species among the nation's "premier gamefish." Those were the Pacific and Atlantic salmon, steelhead trout, and bluefin tuna. The insport catch was: Atlantic salmon, 467,000; coho or silver salmon, 1,221,000; chinook salmon, 503,000; and bluefin tuna, 540. The rod-and-reel landed bluefin tuna averaged 845 pounds each. The Pacific salmon (coho and chinook) catch includes the Canadian Great Lakes catch.

Table 1 also lists the top 16 species of fish landed by anglers in Canada. However, Fisheries and Environment Canada points out that Atlantic cod and mackerel, a significant part of the east coast tidal sport fisheries, are underrepresented owing to the limited survey of anglers who fished those waters. Species are ranked in order of total numbers of fish caught and retained by anglers. The first four (yellow perch, brook trout, walleye, and northern pike) account for over half the total.

The survey is the most comprehensive of its kind ever carried out in Canada, and the first devoted exclusively to sportfishing. It was planned and organized by the Recreational Fisheries Branch of the Fisheries and Marine Service in cooperation with the sport fisheries licensing and management agencies of the provinces and territories. Separate surveys were conducted early in 1976 by all 13 of the provincial, territorial, and federal agencies involved. Some 50,000 questionnaires were mailed out, of which approximately 30,000 completed questionnaires were returned. These were processed by the Recreational Fisheries Branch and provided the basis for the nationwide figures given in the survey report. Several provinces also used their surveys to develop supplementary information for their own specific purposes. It is planned to repeat the survey every 5 years.

"The number of anglers and the dollars involved reflect the importance of Canada's recreational fisheries," said LeBlanc. "I am sure the information provided by the survey will do much to increase public understanding of sport fisheries and should have a significant influence on the future management of Canada's fisheries resources."

A final report giving comparable information broken-down by province, territory, and federal area of jurisdiction will be available in published form later this year. Additional details may be obtained by writing to the Director, Recreational Fisheries Branch, Fisheries and Marine Service, 240 Sparks Street, Ottawa, Ontario, Canada K1A 0E6.

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR), compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, NMFS, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Daily (LSD) reports produced by the Office of International Fisheries, NMFS, NOAA, Washington, DC 20235.

Table 1.—Numbers of fish caught and retained, by species (in thousands).

Fish species	Residents	All nonresidents	Total
Yellow perch (*Perca flavescens*)	37,413	5,898	43,311
Brook trout (*Salvelinus fontinalis*)	37,628	801	38,429
Walleye (*Stizostedion vitreum*)	14,664	6,797	21,461
Northern pike (*Esox lucius*)	12,305	3,990	16,295
Catfish (*Ictalurus nebulosus*)	7,924	143	8,067
Smallmouth bass (*Micropterus dolomieui*)	6,366	1,489	7,855
Rainbow trout (*Salmo gairdneri*)	7,012	729	7,741
Atlantic tomcod (*Microgadus tomcod*)	6,309	—[1]	6,309
Lake Trout (*Salvelinus namaycush*)	5,638	648	6,286
Atlantic cod (*Gadus morhua*)	4,433	—[1]	4,433
Bass (unspecified)	4,068	289	4,357
Largemouth bass (*Micropterus salmoides*)	3,353	665	4,018
Trout (unspecified)	3,658	79	3,737
Perch (unspecified)	3,013	170	3,183
Whitefish (unspecified)	1,967	222	2,189
Atlantic mackerel (*Scomber scombrus*)	1,763	—[1]	1,763
Others[2]	41,582	7,654	49,236
Canada total	199,096	29,574	228,670

[1]Numbers caught and retained are not considered to be statistically reliable.
[2]Although retention of over 18 million rainbow smelt (*Osmerus mordax*) is included, the methods of catch and the size of the species is such that a relative comparison, for purposes of this table, is not meaningful.

Japanese Seiner Takes Indian Ocean Skipjack

The Japanese Kyokuyo Fishery's tuna purse seiner *Wakaba Maru No. 2* (499 GT) sucessfully completed its first voyage in the Indian Ocean, and returned to Singapore on 13 April with 315 tons of skipjack it had caught in 27 days of fishing after leaving the port on 11 March. The vessel left on 21 April for a second fishing voyage in the Indian Ocean after selling the catches to a U.S. packer.

On its first voyage, the *Wakaba Maru No. 2* made a total of 17 sets in waters between 30 and 200 nautical miles off the coast of Sumatra, averaging 11.6 tons of daily catches or 18.5 tons per set. The vessel's highest catches were between 40 and 50 tons a day, a record essentially equaling those in the established fishing grounds off Papua New Guinea. Fish sizes were relatively small nearer the coast, ranging from 1.45 to 2.3 kg, but they grew distinctly larger in the offshore area between 2 and 5.5 kg.

The fishing ground west of Sumatra was chosen because of the infrequent occurrences of stormy weather in this area during the monsoon season. The lack of drifting wood and the presence of strong ground swell rendered contacts with fish schools difficult, but the favorable weather encountered in this area eventually contributed to the good fishing of the first voyage. The *Wakaba Maru No. 2*'s current operation represents the first venture into the Indian Ocean by the Japanese tuna purse seining industry. (Source: FFIR 78-7.)

Canada Puts $1.25 Million Into Atlantic Salmon Work

Funds totalling $1.25 million for the Economic Growth Component of the Canada Works program will be devoted to projects related to Atlantic salmon enhancement in the Maritimes and Newfoundland during the current fiscal year, according to Fisheries and Environment Canada. Fisheries Minister Roméo LeBlanc said that approximately $750,000 will be spent in New Brunswick and Nova Scotia on such projects as design and feasibility studies for a possible major salmon hatchery at Sherbrooke Lake, N.S., and feasibility and site selection studies for a possible new hatchery in northeast New Brunswick.

In addition, part of the funds will be used to complete the new fishway at Tusket River Falls, N.S., and some $100,000 will be devoted to major fish passage feasibility studies on the Nepisiguit and Tetagouche Rivers in New Brunswick. As well as these specific projects, approximately $150,000 of the Canada Works funds will be spent on general surveys of stream obstructions and fish habitats in New Brunswick with a view to improving salmon runs.

The enhancement projects tie in with a comprehensive review and analysis of the Atlantic salmon fisheries started last year by the Canadian government. The review, expected to be completed later this year, is examining the biological, economic, and social factors associated with the Atlantic salmon fishery and will lay the groundwork for a comprehensive management plan, including the feasibility and appropriateness of a major enhancement program for eastern Canada. Commercial fishing for Atlantic salmon in the New Brunswick and Quebec-Gaspé areas has been banned since 1972 as a conservation measure to allow the stocks to rebuild.

British Columbia "B" Salmon Vessels Aided

Licences of 103 salmon fishing vessels in the "B" category in British Columbia, Canada, will be extended by 5 years, enabling them to continue fishing until 31 December 1983, according to Fisheries and Environment Canada. The licences were due to expire at the end of this year.

The vessels involved are those which have been continuously owned and licensed by the original licensees since the Salmon Vessel Licence Control Program was put into effect in 1969. This program, which set a life span of 10 years for the "B" licences, was aimed at improving economic conditions in the west coast salmon fishing industry where the fleet has been too large in numbers in relation to the salmon available.

All other "B" category salmon vessel licences will expire either at the end of this year or at the conclusion of their 10-year life span, depending on when the vessel was designated as falling in this category. This involves a total of about 480 vessels.

Since 1969, vessel owners have had the option of changing from the higher category "A" licence to the lower category "B" licence, which carries a considerably lower licence fee. Roméo LeBlanc, Fisheries Minister, explained that the extension is being granted to the original "B" licensees because they had no choice in the matter when the program was introduced in 1969, whereas those who subsequently opted to switch to the "B" category, did so with the full knowledge of the conditions of the licences.

In order to maintain their status for an additional 5 years, the 103 vessels which are eligible to continue in the B.C. salmon fishery are subject to the following conditions:

1) The licence privilege is nontransferable; 2) the vessel must be owner-operated; and 3) proof must be provided that the vessel is catching salmon each year. LeBlanc added that the appeal process remains open for individuals affected by the decision who feel there are extenuating circumstances in their particular case.

Scotland Nuclear Center Aids Fish Cultivation

The first nursery for commercial breeding of flounder and sole has been constructed adjacent to an electrical nuclear center in Hunterston, Scotland. The nursery, administered by Golden Sea Produce[1], occupies approximately 2.5 hectares next to the center and is

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

complete with large tanks similar to swimming pools where these species are raised for commercial purposes.

The artificially raised fish will be sold to restaurants and individual consumers. If flounder sales this year reach more than the anticipated 100 t, this nursery will produce one-tenth of the total flounder consumption in the United Kingdom.

The fish center will take advantage of the residual ocean water used by the nuclear factory to eliminate excessive heat, but which never has contact with radioactivity. Normally, this water is returned to the sea at higher temperatures, but in Hunterston it is diverted to supply a constant stream of warm water through the breeding tanks. The cold water of the North Sea during the winter months inhibits growth of the fish due to decreased food consumption. At the nursery, the warmer water encourages consumption and growth year round.

Through this species cultivation process, very young fish that by law cannot be caught will be made available for sale. The nursery will also offer large flounder for fillets, directly competing with fishermen who also supply this resource.

In the tanks, each fish is numbered and closely observed by Golden Sea Produce scientists who select the best individuals to create various specialties. This process reportedly may form two separate flounders: Those that grow rapidly and become "baby" flounder, and those that are more conducive to a longer life for the famous fillets.

Although most of the complications with flounder have been resolved, the same is not true with sole. It is a more delicate species and the main problem lies in its refusal to eat, thereby limiting growth.

The nursery's success is due to work initiated more than 10 years ago by the White Fish Authority in the same electrical center. This commission began experimenting with flounder and scientifically proved its ideal adaptability for artificial breeding. The optimum thermal scale for the fish was also discovered in their experiments. Flounder does not flourish in temperatures less than 13°C or above 21°C. Sole, however, can survive at temperatures higher than 8°C, and develops very well between 12° and 19°C. Scientists attempt to reduce the maximum limit to 18°C. (Source: LSD 78-11.)

PRC Elver Exports to Japan Reach Record High

Japanese imports of elvers from Mainland China during March and April this year set an all-time high in volume for this period of the year at nearly 9 tons. The import price was near an all-time high at ¥227,900/kg (US$471/pound at ¥220=US$1) in March, although it dropped to ¥168,700/kg (US$349/pound in April. (Source: FFIR 78-7.)

Japan Okays Papua New Guinea Fishing Terms

Negotiations on a provisional fishing agreement which governs Japanese fishing operations within Papua New Guinea's 200-mile zone came to a settlement earlier this year as the Japanese delegation signed a protocol accepting in full the access and fishing fees as originally proposed by the government of Papua New Guinea.

Under the provisional agreement covering the 9-month period between 1 May 1978 through 31 January 1979, Japanese fishermen within Papua New Guinea's 200-mile zone will pay access fees at the rate of approximately ¥9,900 (US$43.42 at ¥228=US$1) per year for each linear meter of vessel length, and lump sum fishing fee of approximately ¥330 million (US$1.4 million) for the 9-month period. No limit has been placed on the number of vessels or the amount of catches.

The newly agreed access fee represents a considerable jump over the previous fee schedule of about ¥150,000/year/vessel. Japanese fishing vessels in waters off Papua New Guinea include 14 tuna purse seiners, and approximately 400 skipjack pole-and-liners and tuna longliners. Annual catches by this fleet usually consisted of 4,600 by tuna purse seiners, between 2,000 and 3,000 by tuna longliners, and between 5,000 and 50,000 by pole-and-liners.

Japan's total acceptance of Papua New Guinean terms on access and fishing fees was expected to influence the then ongoing negotiation with the Gilbert Islands and one scheduled with the Solomon Islands, according to informed sources in Tokyo. (Source: FFIR 78-7.)

GOOD TUNA CATCHES REPORTED OFF JAPAN

Unusually good catches of bluefin and skipjack tuna have been reported in waters off the Japanese home islands this year. Catches of bluefin tuna up to May totaled 3,000-4,000 t, almost double the amount caught over the comparable period last year. Informed sources predicted that good fishing for bluefin tuna was likely to continue for some time, since the fishing ground, located in a warm water mass surrounded by large stationary cold water masses to the west of the Izu Islands, appeared to be quite stable.

Catches of skipjack tuna this year up to May totaled approximately 20,000 t, more than 1.5 times the catches recorded over the comparable period last year. The Japanese Fisheries Information Service Center was reportedly predicting continued good fishing for bluefin and skipjack tuna off the Japanese home islands into the fall of this year. (Source: FFIR 78-8.)

Black Cod Test Fishing Conducted off Mexico

Five Japanese fishing vessels reportedly arrived in Mexico early this year to undertake test fishing for black cod in waters off the Pacific coast under the license of the Mexican government. The test fishing program, if successful, will be allowed to evolve into a joint venture with an expanded fishing fleet. Mexico reportedly wishes to export the bulk of the catches to the United States, allowing some to be shipped to Japan. (Source: FFIR 78-7.)

NMFS Scientific Reports Published

NOAA Technical Report NMFS SSRF-715. Russell, G. Michael, Abraham J. Barrett, L. Steve Sarbeck, and John H. Wordlaw. **"Bottom obstructions in the southwestern North Atlantic, Gulf of Mexico, and Caribbean Sea."** September 1977. 21 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

Lists of bottom obstructions are provided to aid in avoiding potential hazards to fishing gear. Locations, depth, gear type, and damage received are included. Within the regions, the following numbers of obstructions are identified: 267 southeastern North America, 320 Gulf of Mexico, 23 West Indies, 119 Caribbean Sea, and 59 northeast coast of South America.

NOAA Technical Report NMFS Circular 404. Bortone, Stephen A. **"Revision of the sea basses of the genus Diplectrum (Pisces: Serranidae)."** September 1977. 49 p.

ABSTRACT

Twelve species of *Diplectrum* are recognized: three western Atlantic (*D. formosum, D. bivittatum,* and *D. radiale*) and nine eastern Pacific species (*D. pacificum, D. conceptione, D. maximum, D. rostrum, D. labarum, D. eumelum, D. sciurus, D. macropoma,* and *D. euryplectrum*). All species are hermaphroditic and possess an ovarian sinus in the posteriormost gonadal area. *Diplectrum* osteological characters aid in defining the genus and in comparing its taxonomic status with *Serranus*. Definitions of the Serraninae and Serranidae are modified as a result of *Diplectrum* osteological characters. The genus is basically restricted to the warm tropical-subtropical coastal areas of the new world. *Diplectrum bivittatum,* however often occurs at insular localities, and *D. conceptione* occurs in colder, temperature Peruvian waters. *Diplectrum formosum* is considered to have a northern subspecies, *D. f. formosum,* and a southern form, *D. f. radians; D. bivittatum* is also composed of two supspecies: *D. b. bivittatum* from South American and Caribbean areas and *D. b. acrucarium* from the Gulf of Mexico. An intermediate population occurs in the vicinity of southern Florida. *Diplectrum radiale* and *D. pacificum* are "geminate species" and similar morphologically. *Diplectrum mexicanum* is considered a junior synonym of *D. macropoma*.

NOAA Technical Report NMFS Circular 405. Pawson, David L. **"Marine flora and fauna of the northeastern United States. Echinodermata: Holothuroidea."** September 1977, 15 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

The holothurian fauna of the east coast of the United States from southern New Jersey to Nova Scotia, to depths of 200 m, comprises 21 species in 17 genera and 8 families. An introduction to the general biology and morphology of the holothurians, systematic characters and examination procedures, and a selected bibliography are included, together with an illustrated key to the species, an annotated systematic list, and an index. Affinities of this fauna are chiefly boreal; some species also occur south of Cape Hatteras, while others are essentially Arctic in distribution.

NOAA Technical Report NMFS SSRF-716. Wilk, Stuart J., Wallace W. Morse, Daniel E. Ralph, and Thomas R. Azarovitz. **"Fishes and associated environmental data collected in New York Bight, June 1974-June 1975."** September 1977. 53 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

Tabulations of fishes and associated environmental observations are given for 700 trawl stations made during 30 collecting intervals in the New York Bight from June 1974 to June 1975. Summary tables included give the following information: collecting interval data (vessel, dates, stations sampled, gear, and area); station data (date, location, time of day, total catch, and environmental observations); and catch data for 127 species, representing 67 families (location, number, and weight). The 10 most frequently collected species were: *Merluccius bilinearis* (456 stations), *Scophthalmus aquosus* (419), *Raja erinacea* (411), *Urophycis chuss* (409), *Pseudopleuronectes americanus* (363), *Hippoglossina oblonga* (325), *Lophius americanus* (305),

Peprilus triacanthus (284), *Paralichthys dentatus* (272) and *Squalus acanthias* (224).

Groundfish Trawlers of Three Nations Compared

A fisherman aboard a groundfish trawler makes more money aboard a southern New England vessel than he does aboard those in Norway and Iceland. For the vessel owner, though, return to his investment is higher in Norway than in the United States.

Those are two of the conclusions reported by University of Rhode Island resource economist Andreas A. Holmsen in "Economics of Small Groundfish Trawlers in Iceland, Norway, and Southern New England." The Sea Grant study compared data of the 1974 operations of 65- to 90-foot trawlers from those nations. Included were such aspects as vessel characteristics, fishing effort, landings, and price and cost breakdowns.

The publication also contains descriptions of the underlying reasons for many of the cost items, such as insurance and finance costs and the share systems on the vessels. The volume can be obtained by ordering P 549 from the URI Marine Advisory Service, Narragansett Bay Campus, Narragansett, RI 02882.

SHRIMP DISEASES HANDBOOK REVISED

The "Handbook of Shrimp Diseases" by S.K. Johnson (TAMU-SG-75-603), published by the Sea Grant College Program of Texas A&M University, has been revised and reissued. The handbook is designed as an information source and field guide for shrimp mariculturists, commercial fishermen, and others interested in parasites or abnormal conditions of shrimp.

Information is presented on life cycles and general biological characteristics of disease-producing organisms which spend all or part of their life cycles with shrimp. Detailed descriptions and illustrations of common parasites and commensals of penaeid shrimp are included. The 20-page booklet, with 12 illustrations, 28 black and white and 12 color photographs, is available free of charge, from: Sea Grant College Program, Texas A&M University, College Station, TX 77843.

Oyster Seed Hatchery Manual Is Published

A "Manual for Design and Operation of an Oyster Seed Hatchery" has been published by the Virginia Institute of Marine Science as Special Report No. 142. Authored by John L. Dupuy, Nancy T. Windsor, and Charles E. Sutton, the 104 page volume represents the completion of 7 years of research and cooperative work with the oyster industry in developing a totally integrated hatchery system. The book's 49 illustrations include both photographs and line drawings.

Major areas covered include: Environmental considerations; biology of the production of gametes and spawning of adult oysters; culture of oyster larvae; culture of algal food; culture facilities; and production and cost and income flow schedule.

The volume is available ($10.00, hardbound; $7.50, looseleaf; and $5.00, softbound) from the Sea Grant Communications Office, Virginia Institute of Marine Science, Gloucester Point, VA 23062. Checks should be made payable to the "Virginia Institute of Marine Science."

"Creamy Fish Bites" Booklet Available

The New York Sea Grant Institute has published a 31-page booklet entitled "Development of Products From Minced Fish: Creamy Fish Bites." Copies of this item are available from: NTIS, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. The cost for a paper copy is $4.00. Order by number: PB-277 094/9GA; PC A03. Make check payable to: National Technical Information Service.

Articles, Records on Marine Angling

Publication of "World Record Marine Fishes," 1978 edition, has been announced by the International Game Fish Association. It is the official guide to world saltwater fishing records and international angling regulations.

This edition has been expanded to 240 pages for the first time it includes illustrations and text for species on which the IGFA maintains records. The design and format are also new—line class listings are given in both metric and customary U.S. designations.

The data and articles are presented in seven sections, plus appendices listing worldwide marine game fish tagging programs, an illustrated guide to fishing knots and splices, a glossary of sportfishing terminology, and conversion tables for weights and measures for anglers.

Section 1, on the IGFA, gives the organization's officers and representatives, its philosophy and goals, membership programs, and data on the library of fishes. Section 2 presents a variety of short articles on marine game fishing by recognized marine angling authorities. Drawings and details of the officially recognized marine game fish from albacore to yellowtail are presented in Section 3. Data for each species includes the scientific name plus common names used in various nations, distribution, body features, coloration, behavior patterns, fishing methods and other general information on food value, natural history, sporting qualities, etc.

International angling rules formulated by the IGFA to promote ethical and sporting angling are covered in Section 4 while Section 5 details the annual IGFA fishing contest. World record categories, rules and preparation of record claims are given in Section 6. Finally, Section 7 lists the world records all-tackle and line class world records granted as of 1 January 1978 for 67 categories of marine game fishes.

The paperback volume is available from the International Game Fish Association, 300 East Las Olas Blvd., Ft. Lauderdaule, FL 33316 for $5.95.

The Florida Lobster, Tagged Shrimp, and Artificial Reefs

. . . . **The Atlantic Fisheries Technological Conference** is scheduled for 5-8 November 1978 at the Williamsburg Lodge, Williamsburg, Va., reports John Long, Secretary, 23rd AFTC. It's purpose is to provide a forum where fisheries technologists can discuss research objectives and methods, exchange research concepts and hypotheses, and present informal reports on researches completed or in progress. More than 50 speakers will participate and proposed topics include energy, underutilized species, economics, seafood composition, quality, and nutrition. Forms for papers, reservations and registration are available from John Long, Secretary, 23rd AFTC, Department of Food Science and Technology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061 . . . .

. . . . **Intensively exploited for many years** by commercial trap fishermen and recreational divers, the Florida lobster, *Panulirus argus*, fishery is showing signs of overfishing—small catches of small lobsters despite greatly increased effort—reports the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Thus, specialists from that School, the University of Florida's Department of Food and Resource Economics, and the Florida Department of Natural Resources have combined forces to formulate management policies aimed at protecting the stock while helping the fishermen keep lobster on the menu . . . .

. . . . Texas, and other Gulf coast shrimpers, **have been harvesting some very valuable tagged shrimp** along with their regular hauls in recent weeks, the Texas Parks and Wildlife Department reports. The tagged shrimp are part of a scientific study being conducted cooperatively by that Department, the National Marine Fisheries Service, Texas A&M University Sea Grant Program, Mexico's Instituto Nacional de Pesca, and other Gulf coast states. The aim is to learn more about the movements, migrations, growth rates, and mortality of brown shrimp, the most important commercial marine species for Texas fishermen. The tagged shrimp, if picked by computer, could bring from $50 to $200, if the whole shrimp with tag attached is returned to state or Federal fisheries biologists . . . .

. . . . A recent South Carolina Marine Resources Division study indicates that **anglers there spend some $10 million per year fishing at artificial reefs.** That's about 20 percent of the total economic impact of all offshore fishing on the State of South Carolina during 1977. Meanwhile, the Division filled a 100-foot tugboat with 6,000 baled tires and sank it on their 4KI artificial fishing reef 3 miles off Kiawah Island. That reef, which now consists of 36,000 tires, 7 ship hulls, and 70 discarded auto bodies, provides good angling for sheepshead, black sea bass, mackerel, and cobia. It is one of nine such reefs built by the Department to enhance coastal fishing . . . .

. . . . To help **prevent the growing problem of crab pot theft,** the South Carolina Wildlife and Marine Resources Department has instituted a new system of marking crab traps. In July, all commercial crab fishermen were given 60 days to mark each of their pots with special identification tags provided by the Marine Resources Division. Crabbers have for years been required to mark their pot floats with identification numbers, but that system has not prevented the theft of the crab pots, the Department reports. The tamper-proof plastic tags were provided at no cost to the crabbers by conservation officers who placed them on the pots . . . .

. . . . Biologists from South Carolina and Georgia began a cooperative study, funded in part by the National Marine Fisheries Service, early this year to determine **how better to manage the declining population of shad** and other related fish species, the South Carolina Wildlife and Marine Resources Department reports. The shad catch in South Carolina peaked at 577,000 pounds in 1889 and has declined ever since, according to the Department. Last year's commercial landings for the state totaled about 80,000 pounds worth about $53,000, although the Department believes that much of the shad catch may go unreported because of the nature of the fishery. The study will involve interviews with fishermen and seafood dealers, as well as review all research done over the years on these fish in both states . . . .

. . . . **Cheaper animal fats, substituted for more costly fish oils** in commercial fish rations, could save trout and salmon ranchers, as well as state and Federal hatchery operators, a considerable amount of money, according to researchers at Oregon State University's Department of Food Science and Technology. Testing to see if the fish were eating more fish oil than they needed, the researchers found that the fish require a diet containing 10 percent fish oil instead of 50 percent. In trying various cheap, readily available energy foods to replace fish oil, the researchers found that trout and salmon grew well on a diet containing lard, and fish feed manufacturers are now reported looking at ways to incorporate animal fats into commercial fish rations . . . .

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1969a, 1969b, 1969c, etc.).

Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 1107 N.E. 45th Street, Room 450, Seattle, WA 98105.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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